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VOLUME 24

Trinity

Edited by

K. T. Bainbridge

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PREFACE

This volume is intended as a comprehensive record of the July 16, 1945 atomic bomb test at the Alamogordo Air Base. Chapters one through five describe in considerable detail the events leading up to "Zero", the moment at which the bomb was detonated. Chapter six, which was originally intended as a summary only of the radiation observations at Trinity, was not written until the summer of 1946. During the intervening time, the air burst test at Bikini was made and it was considered useful that a comparison be included between this latter test and the Trinity data.

Chapters seven through ten summarize all other experimental observations made at the Trinity test. Chapter eleven is a report by the editor of this volume relative to possible future atomic bomb tests which might be scheduled to investigate the behavior of bombs of different design than the Model 2 Implosion Bomb used at Trinity, Nagasaki, and Bikini.

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VOLUME 24

THE JULY 16, 1945 TRINITY BOMB TEST

Editor: K. T. Bainbridge
D. Inglis (for reports)

Contents as of 10 December, 1945

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CHAPTER 1

INITIAL PREPARATIONS FOR THE TEST

by K. T. Bainbridge

Sec. 1.0 INTRODUCTION

Preparations for the Trinity test were started in March 1944 which culminated in a 100 ton rehearsal shot on May 7, 1945 and the final gadget test shot on July 16, 1945. The main purpose of this volume is to aid in the planning for any future test by furnishing a review of the preparations for and results of the above tests. The reports on results are included in their complete form as the purpose of this volume can only be met by supplying complete details of the equipment design and calibration, with the results obtained. The main editorial work has been done by D. Inglis, who has acted as editor for all LA and LAMS reports. The sections not otherwise specified were prepared by the writer.

The purposes of the present volume are:

(1) To put on record the development, scope and type of operations involved in the July 16, 1945 atomic bomb test with recommendations for future operating procedure;

(2) To collect in one place all the reports relating to the apparatus and results, planning and administration.

A test of the atomic bomb was considered essential by the Director and most of the group and division leaders of the laboratory because of the enormous step from the differential and integral experiments, and theory, to a practical gadget. No one was content that the first trial of an F.M. gadget should be over enemy terri-

tory, where if the gadget failed, the surprise factor would be lost and there was considerable chance that the enemy would be presented with a large amount of active material in recoverable form. The only thing which could finally settle the many questions current prior to the test was an actual experiment with full instrumentation, and plans were made for yields from 100 to 10,000 tons with the most probable value 4000 tons (July 10, 1945). The safety of personnel and structures was insured for yields as great as 200,000 tons. The final functioning of the bomb showed that the prior work had been excellent in every respect and no vital factor had been overlooked.

1.1 TESTS PLANNED

The first formal arrangements for preparations for an atomic bomb test were made in March 1944 when Group X-2 was formed in the Explosives Division headed by G. B. Kistiakowsky. The duties of the X-2 group under K. T. Bainbridge included making preparations for a field test in which blast, earth shock, neutron and gamma radiations would be studied and complete photographic records would be made of the explosion and any atmospheric phenomena associated with the explosion. This work was set up under Section X-2C with L. Fussell, Jr. in charge. Ensign G. T. Reynolds and D. F. Hornig of Division 2 of the NDRC were recruited to head the work on blast and earth shock measurements. D. L. Anderson had charge of the work on meteorological measurements and equipment for entering the crater area for recovering samples of radioactive materials. P. B. Moon was in charge of the preparations for nuclear

measurements. The section grew to a total of 25; its membership as of February 1, 1945 is given in the X-2 personnel report (appendix Ser. No. 1). All optical and photographic studies were prepared by J. E. Mack's group in another division.

The first systematic account of the test plan is given by a memorandum dated September 1, 1944, by Fussell and Bainbridge (appendix Ser. No. 2). Earlier discussions with V. Weisskopf are in report Ser. No. 3 of the appendix. These plans were based on the assumption that a large steel vessel (Jumbo) would enclose the gadget (25 and [redacted]) so that the active material could be recovered in the event of a complete fizzle. The planned tests included provision for a yield of 200, to 10,000 tons:

		Designation in Chapter 10
I.	Blast Measurements	III Blast
	a/ Piezo electric gauges	III, 1
	b/ Paper diaphragm gauges	III, 4d
	c/ Condenser blast gauges	III, 2a
	d/ Barnes' boxes	Not used
	e/ Condenser gauge blast measurement from plane	III, 2b
II.	Ground Shock Measurements	III Earth Shock
	a/ Geophones	III, 1
	b/ Seismographs	III, 4
III.	Neutron Measurements	
	a/ Gold foil	II, 2b
	b/ Fast ion chamber	Not used in this form

		Designation in Chapter 10
IV.	Gamma Rays	
	a/ Recording in plane, dropped "gauges"	Not used
	b/ Gamma ray sentinels	V, 1
V.	Nuclear Efficiency	II, 3a
VI.	Photographic Studies	
	a/ Fastaxes at 800 yds.	Gen. Phenomena IV, 1a, b, c
	b/ Spectrographic studies Radiation characteristics	Rad. Charact. IV, 1a, b
	c/ Photometric	Rad. Charact. IV, 3a
	d/ Ball of fire studies	Gen. Phenomena IV, 2a IV, 3a
VII.	SCR-584 Radar	Gen. Phenomena IV, 1f
VIII.	Meteorology	VI

Additional nuclear measurements are considered in three reports by P. B. Moon (appendix Ser. No. 4), who in these reports anticipated some of the experiments which were later adopted in March 1945.

1.2 CHOICE OF A SITE

Eight different sites were considered from map data:

Tularosa Valley
Jornada del Muerto Valley
Desert training area near Rice, California
San Nicolas Island off the coast of So. California
The lava region south of Grants, New Mexico
Southwest of Cuba, New Mexico and north of Thoreau
Sand bars which form the coast of So. Texas located 10 miles from the main coast
San Luis Valley region near the Great Sand Dunes National Monument in Colorado

The scientific considerations required that the site be flat to minimize extraneous effects on blast. The large amount of optical information desired required that on the average the weather should be good with small and infrequent amounts of haze or dust and relatively light winds. Ranches and settlements should be distant to avoid possible danger from the products of the fission bomb. Another major consideration was the requirement of minimum loss of time in travel by personnel and transportation of equipment between Project Y and the site.

The main consideration of the Military Intelligence was the question of security and complete isolation of the activities of the test site from activities at Project Y.

The major problem of the military was the construction of a camp and facilities for living in whatever flat and desolate region was selected.

Auto trips were made to the regions north and south of Grants and Thoreau, the Tularosa basin, the Jornada del Muerto Valley, and the desert training area. Aerial surveys were made at low altitude by one or another of the group, K. Bainbridge, R. W. Henderson, Major W. A. Stevens and Major P. deSilva, over the same areas. The choice finally narrowed to either the Jornada del Muerto region in the northwest corner of the Alamogordo Bombing Range, or the desert training area north of Rice, California.

The final choice of site was made after consultation with General Ent of the Second Air Force on September 7, 1944, who

gave permission for a party to approach the Commanding Officer of the Alamogordo Bombing Base to seek an area approximately 18 x 24 miles within the base. Four locations were discussed and finally the northwest corner of the Alamogordo Air Base was selected, latitude 33°28' to 33°50', longitude 106°22' to 106°41'. This permitted separation on the north and west of a minimum of 12 miles to the nearest habitation, which was great enough so that no trouble could be expected from shattering of ranchers' windows by the blast even under conditions of 100% yield. On the east the area under government control extended 18 miles and adjoined the "Malpais" area. The nearest towns in any direction were 27 to 30 miles away. The prevalent winds were westerly.

Arrangements were made with the Second Air Force for a 6" to the mile mosaic to be made of a strip 6 x 20 miles including point 0 at the center to aid in locating stations. A transparent overlay was made for this map with 10,000-yard scaled arms so that the main instrument shelters could be rotated with respect to point 0 and the whole overlay could be shifted over the mosaic so that shelter positions could be specified which would not be in washes. A ground survey group with this map laid out points A and 0 and set a tentative location for point B which was finally adopted following the discussions with Col. Wriston of the Alamogordo Air Base.

The usefulness of aerial mosaics cannot be over-emphasized, both for the exploratory work of the region and in the final precise planning. A great deal of time was wasted in land surveys

because of inadequate maps; the good maps were not obtained in time to be of any use. Maps had to be requested through the Security Office, in June 1944, and in many cases were not received at all. The maps finally used were obtained by ordering all of the geodetic survey maps for New Mexico and southern California, all of the coastal charts of the U.S. and most of the grazing service and county maps for the state of New Mexico through other sources which normally had some use for maps. Aerial mosaics and land status maps were scrounged. This gave enough maps with which to work.

1.3 APPROVAL OF BASE CAMP AND TEST SITE

The original plans for the base camp as drawn up by Capt. S. P. Davalos, Bainbridge and Fussell on October 10, 1944 are given in Ser. No. 5 of the appendix. A survey of the proposed scientific measurements at the site is given in a memorandum from G. B. Kistiakowsky to J. R. Oppenheimer dated October 13, 1944 (appendix Ser. No. 6), giving justification for the construction and equipment requirements for the test. These two documents were transmitted to General Groves on October 14, 1944, followed by a teletyped request for a decision whether or not a test would be run at all, and approval was sought for the proposed plans. The plans were approved so that early in November contracts were let through Major Stevens for the initial construction, which had to be expanded later, in May 1945, to take care of the expansion in activities planned for the final test shot in July. The camp was completed late in December 1944 and a small detachment, about 12

men, of Military Police under Lt. H. C. Bush took up residence there to guard the buildings and shelters prior to the completion of the mess hall and improvements in the roads. The choice of Lt. Bush as Commanding Officer of the Trinity Base Camp was a particularly fortunate one. The wise and efficient running of the Base Camp by Lt. Bush contributed greatly to the success of the May 7 and July 16 tests. It was a "happy camp", to borrow a Navy term. The excellent camp morale and military-civilian co-operation did much to ameliorate the difficulties of operation under primitive conditions.

1.4 CONSTRUCTION OF JUMBO. RECOVERY METHODS

In the winter and spring of 1944 the possibility that the first test bomb would not work at all was constantly in mind. Discussions had been held between S. Neddermeyer, G. B. Kistiakowsky, J. R. Oppenheimer and others to consider the construction of a large pressure vessel which would be able to contain the active material and products of the explosion of high explosive, if the operation of the first atomic bomb should be a complete fizzle. The need for the containing vessel was based on the uncertainties of the behaviour of the bomb and the desirability of conserving active material.

The engineering, design and procurement of the pressure vessel (Jumbo) was handled by R. W. Henderson and R. W. Carlson of Section X-2A among their other duties, and the testing was carried out by Lt. W. F. Schaffer, who headed Section X-2B and who assisted in the measurements of pressures and deformations by G. M. Martin,

T/3 B. Bederson, T/4 J. A. Hofmann and T/4 K. W. Henderson of Fussell's section under P. B. Moon's direction. The early calculations by Bethe, Weisskopf and Hirschfelder of the behaviour of high pressure vessels were not fully sustained by experiment, as the best obtainable machine steel vessels could not contain more than about 50% of the predicted charge. R. W. Carlson (see LA-390) made a more complete analysis of the dynamic mechanics of the vessel and of the stresses involved in the walls. R. W. Henderson completed the new final detailed design for Jumbo which ultimately was built by Babcock & Wilcox. Scale experiments proved the soundness of the new design. The 214-ton Jumbo was shipped to the test site and finally erected a week or two prior to the test (Fig. 1) at a point 800 yards from its original location, since by that time its use in the July test had been abandoned, for reasons to be considered later.

Other methods for recovery of the active material were explored by Lt. W. F. Schaffer. One method provided a sand pile covering the bomb which "contained" the explosion of the H.E. required for the initiation of the bomb and would permit recovery of the active material from a dud shot. The amount of sand required would not be small in its muffling effects on a full scale atomic explosion. All proposed blast, earth shock, and optical measurements would be seriously compromised or rendered entirely useless if any of the recovery methods should be used. Another method required making a cone in the ground, mounting the bomb, then filling the cone with sand, and finally covering with sand in a cone above

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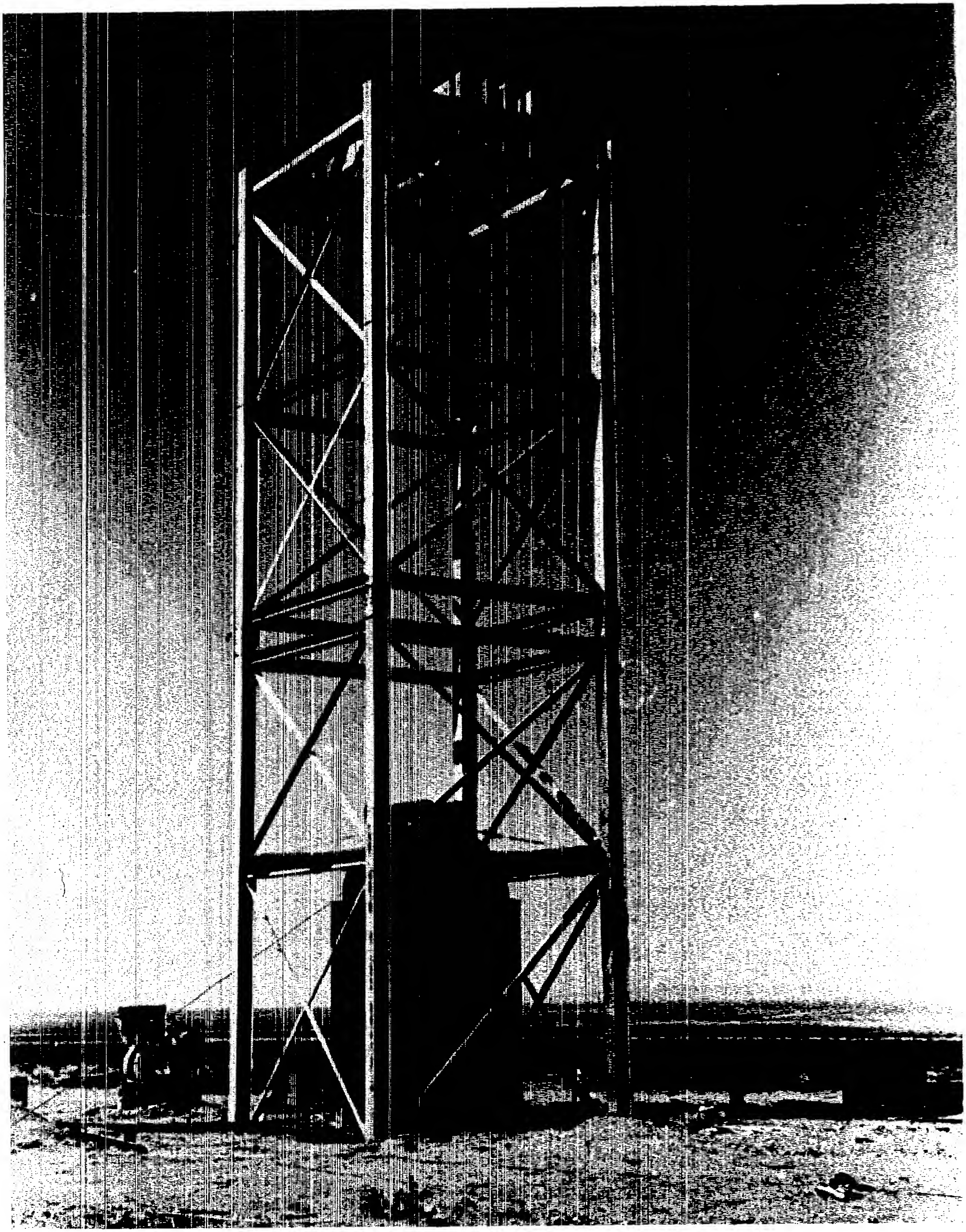

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ground level. This reduced the amount of sand required to half that in the previous case. A ratio of weight of sand to weight of explosive of 15,000 to 1 was required for the recovery of the material in this case.

Finally a water recovery method was investigated in which model bombs surrounded by an air space were suspended in a cylindrical tank of water whose weight was 50 to 100 times the weight of the bomb's high explosive. The water recovery method was investigated in detail, as it was the only method which gave any hope of recovery of 25 in the event that a 25-28 gadget were used, as mechanically it gave promise of non-mixing and non-burning of the core in the event of a nuclear fizzle.

All chemical methods of recovery, whether from Jumbo or from sand, were studied by R. B. Duffield's Group CM-10.

It is interesting to recall that had a dud shot been made in Jumbo, the active material dispersed in the condensed steam and tamped by Jumbo's walls could be supercritical if no boron were added to prevent the reaction.

All recovery methods were abandoned in March 1945 when it was no longer possible to make test plans which did not interfere, one set of plans covering the case of firing with Jumbo, the other being for an air shot with no attempt at recovery of the active material in the event of a fizzle. Any straddle would have meant that neither test set-up would be ready on time. Recovery methods were abandoned as the greater promised production of active materials made it less essential to save the material in the event

of a failure. Also confidence in the ultimate success of the bomb increased. A major factor in the decision was the increased protest against the use of a containing vessel as the vessel proper would spoil a very large share of the measurements. Certainly blast data experiments would be greatly affected, and good blast information was one of the main objectives of the test. It was important to study the blast effects under conditions which could be translated into combat use conditions in order finally to obtain the maximum military effect of the bomb. Jumbo contained 214 tons of steel which would be vaporized for yields exceeding 500 tons; at these yields of the atomic bomb the steel would be vaporized and later burnt, producing pressure effects which could not easily be analyzed. If the explosion were in the region 100 to 300 tons, the fragments from Jumbo would be a hazard to gauge lines, equipment and personnel, and the energy abstracted by the fragments would be uncertain and difficult to correct for in measuring the total energy yield.

1.5 EXPANSION OF THE TRINITY PROGRAM, MARCH-MAY 1945

Preference rating on the scientific measurements had gradually descended almost to zero starting in August 1944, and continued very low until the end of February 1945. This resulted from difficulties in the development of the detonating system for the F.M. which required more manpower on research and development work than could be provided by normal recruiting. The urgency was so great to produce a satisfactory detonating system for the F.M. that all but two men of Section X-2C were applied to the development of the detonating

system and other jobs which had higher priority than the preparations for the test. Studies continued on condenser blast gauges, earth shock geophones, paper box blast gauges and other equipment in preparation for the test, particularly the procurement of piezo electric gauges, radiosondes, radars, pilot balloon equipment and Heiland recorders so that much equipment was purchased for use in the test, but there was not sufficient manpower for all of the development, calibration and testing which was needed.

The detailed status of the preparations for the Trinity test made by Fussell's group as of January 1, 1945 is given in the appendix, Ser. No. 7. This summarizes the basic layout to which experiments were added or new methods substituted as demanded by increased knowledge and predictions of the physical effects to be encountered. Fussell has written a brief summary:

> "It has been suggested that I prepare a short description of the work carried on in E-9 and X-2C in the early stages of preparation for Trinity.
>
> "The layout of the test site had been determined, roads were constructed, and shelters for instruments and personnel had been built. Shelter design was by Carlson and Reynolds. Earth samples in the region of the craters had been obtained; this work was supervised by D. L. Anderson with the help of Blake, Breiter, Rohlfing and Fortine. Some meteorological equipment had been obtained through the efforts of Anderson, who made a few test soundings.
>
> "A considerable number of blast gauges, of several

"varieties, had been obtained and calibrated by Reynolds, who also designed and built a number of special geophones. A study of the expected blast pattern by Reynolds had fixed the locations for the blast and earth shock instruments. A design for an airborne condenser gauge and radio informer had been worked out by Blake, Rohlfing and Fortine; Hornig contributed to the condenser design.

"A number of cables were installed, to determine electrical and weather characteristics; this work was done by Blake, Breiter, Rohlfing and Fortine.

"A considerable program of pressure measurement in scaled Jumbino models was supervised by Moon and performed by Martin, Bederson, Hofmann, Henderson.

"The status of the nuclear preparations is covered by memo from Moon to Manley dated 14 February 1945 (Ser. No. 8 of the appendix). Attention should be called particularly to the contributions by Hofmann and Breiter to the delayed ionization (sentinel program); to D. L. Anderson's work in obtaining, designing, and assembling M-4 tanks and lead (which was taken over later by H. L. Anderson); and to the many ideas and over-all supervisory load carried by Moon."

No directive could be given for a test because of the loose ends cropping up in bomb development, and until those were taken care of there would not be a bomb in any case.

Finally with the completion of almost all of the physics research essential to the bomb, J. R. Oppenheimer proposed in

March 1945 that section X-20 complete the detonating system development and that the various groups in R Division should consider the completion of different phases of the test project, which was christened "Trinity" or "TR".

CHAPTER 2

100 TON TNT CALIBRATION AND REHEARSAL SHOT

2.1 PLAN AND ORGANIZATION

A 100 ton shot was proposed in the summer of 1944 to accomplish a dual purpose: (1) To provide a full dress rehearsal in preparation for the later gadget test; (2) To provide calibration of blast and earth shock equipment. Very little was known experimentally from prior work of blast effects above a few tons of H.E. The results on blast and earth shock would aid in determining proper structures for withstanding these effects for the final shot by using proper scale factors. The center of gravity of the 100 ton stack was made 28 feet above the ground in scale with the 4000-5000 tons at 100 feet height expected in the final test.

The organization outlined below was set up and was expanded rapidly. This group served for the May 7 100 ton shot.

PROJECT TR

K. T. Bainbridge	Director, Project TR
Lt. H. C. Bush	C.O., Trinity Camp
Lt. R. A. Taylor	Security
Capt. S. P. Davalos	Engineer Detachment, Trinity
W. G. Penney	Consultant, Shock and Blast
V. Weisskopf	Consultant, Nuclear Physics Problems
S. Kershaw	Safety Committee Advisor
Lt. W. F. Schaffer	H.E. Tower and Stacking
TR-1 J.H.Williams (R-2)	Services
	Radio and Telephone
	Construction
	Communications
	Transportation
E. Marlowe	Timing
	Locking
	Remote Control Circuits
R.J. Van Gemert	Purchase and Follow-Up

TR-2	J.H.Manley (R-3)	Shock and Blast
1.	W.C.Bright	Condenser Gauges
2.	R.L.Walker	Piezo Gauges
3.	J.C.Hoogterp	"Paper" Box Gauges
4.	T.Jorgensen	Mechanical Impulse
5.	H.H.Barschall	Excess Velocity
6.	J.H.Coon	Earth Displacement and Crater Dimensions
7.	J.H.Coon	Geophones and Seismographs
TR-3	R.R.Wilson (R-1,R-4)	Nuclear Measurements
	P.B.Moon	Consultant
1.	R.R.Wilson (R-1)	Prompt Measurements
2.	J.H.Williams (R-2)	Delayed n
3.	E.Segre (R-4) and P.B.Moon	Delayed γ
4.	Dr.L.H.Hempelmann	Health
5.	H.L.Anderson (F-4)	Conversion
TR-4	J.M.Hubbard	Meteorology
	Lt.C.D.Curtis	SCR-584 Radar and Ball of Fire Plotting

Associated Groups or Teams

TR-5	J.E.Mack (G-11)	Spectrographic and Photographic
TR-6	B.Waldman (O-4)	Airborne Measurements

In addition

F.G.Blake, Jr.	Condenser
Ens. G.T.Reynolds	Shock and Blast
D.L.Anderson	Meteorology and Sample Recovery

were associated until their work could be transferred from the old section X-2C.

2.2 FIRING OF 100 TON SHOT

The complete cooperation and unselfish devotion of all to the work at hand enabled the 100 ton shot to be fired on May 7, 1945. The scheduled date had been May 5 but was extended to May 7 to allow installation of additional equipment.

Several requests for an additional time extension had to be

refused. Any delay in starting the additional wiring, shelter construction, and completion of roads in preparation for the main show would have delayed the atomic bomb test and put intolerable burdens on the whole group in order to be prepared for the July test. In order to keep the schedule for the main test within the bounds of human capabilities it was essential to get the May 7 shot out of the way.

The greatest strain falls on those responsible for timing services, as the trials of signal lines, remote actuating circuits, and test calibrations must continue for long periods and at all hours. The relay system designed by Marlowe accomplished accurately all of the timing and actuating functions required. The final timing of equipment in the last 45 seconds was performed by a combination of a rotating drum and pin actuated switch mechanism designed by J. L. McKibben and electronic timing devices provided by the Electronics Group.

The actual time of the explosion was 4:37:05.2 ± 0.1 seconds A.M. MWT, May 7, 1945. The location of the blast was latitude 33°40'0", longitude 106°28'0".

The "Arming Party" responsible for the final closing of the firing line switches and for the safety of all personnel comprised K. T. Bainbridge, TR Head, Lt. H. C. Bush, C.O., E. W. Marlowe, Timing, Sgt. W. Stewart, H.E., and John Anderson, Security. There were three M.P. guards who came in from N-10,000, W-10,000 and S-10,000 at 2:00 A.M. and returned to the shelters to make a final check on personnel in the field who might be trying to do last-

minute work.

The switches at S-10,000 were not closed until every single individual who had been allowed within the test area was accounted for and had been checked in at his post of duty. The checking took about 30 minutes for the May 7th shot and 15 minutes for the July 16th shot under the system set up by Lt. Bush and Bainbridge.

The keys to the three locked boxes at Z, S-1500 and S-10,000 were in Bainbridge's possession as the responsible head of the operation.

2.3 RESULTS OF THE 100 TON SHOT

R. C. Tolman wrote on May 13, 1945 a memorandum to General Groves which is a concise summary of the results of the "First Trinity Test." Excerpts follow from this report. The outline follows that presented in a Tuesday night colloquium by Bainbridge summarizing Trinity plans. The relation of the 100 ton test to the July 16 test is given in tabular form in Chapter 10 of this volume. Detailed reports are indexed in the tabulation.

REPORT ON FIRST TRINITY TEST

by R. C. Tolman

2.3-1 Purpose of Test

This memorandum gives a brief description of results obtained in the first Trinity Test carried out on 7 May 1945. The purpose of this test was to obtain preliminary information, from the detonation of 100 tons of ordinary high explosive, as to the success to be expected from observational methods and from administrative procedures proposed for the final test with nuclear explosive.

The section headings in this memorandum agree with those in my memorandum of 17 April 1945 on the "Program for Trinity Test", to which reference may be made for a clearer understanding of the purpose of the whole program. The present memorandum is written at a time when the data provided by the first test have for the most part not been worked out, but when it is possible to give an overall picture of the character of the test, and to state which measurements appear to have failed or succeeded.

2.3-2 General Character of the Test

The test was carried out with 100 tons of high explosive stacked on the platform of a twenty foot tower as described in more detail in the previous memorandum.

Measurements of blast effect, earth shock, and damage to apparatus and to apparatus shelters, were made in general at "scaled-in" distances as compared with the distances proposed for the final shot. Measurements to determine "cross-talk" between circuits, and photographic observations were in general carried out at the full distances proposed for the final shot.

The scheduling of the test was advanced from the original date 5 May to 7 May to allow for further introduction of apparatus. On the basis of continuing weather forecasting, the time selected for the shot was 4:00 A.M., and it was actually pulled off with a delay of only 37 minutes to allow the observation plane to get

properly ranged for dropping its air-borne instruments.

The detonation was evidently high order. It led to the production of a highly luminous sphere which then spread out into an oval form. This was followed by the ascent of the expected hot column which mushroomed out at a height of some 15,000 feet, at a level where atmospheric instability was indicated by meteorological observation, and then drifted eastward over the mountains. The illumination and sound were detected at the Alamogordo Air Base 60 miles away, by an observer who had been prewarned. Earth shock was imperceptible at 10,000 yards and at the base camp 10 miles away. The explosion seems to have aroused little comment in neighboring towns.

2.3-3 Program of Measurement and Observation

As described in more detail in the previous memorandum, the primary measurements and observations to be taken in the final test may be grouped under the following four headings:

1) Behaviour of the Implosion.

2) Nuclear Energy Released.

3) Damage Effects Produced.

4) Overall Behaviour of the Explosion and Its After Effects.

In this preliminary test, which involved neither an implosion nor nuclear explosive, only subsidiary experiments could be carried out in connection with the first two headings.

In addition to the program of primary measurements and observations, there were also programs of measurement in connection with meteorological observations and health control.

2.3-4 Organization for Carrying Out the Program

The organization for carrying out the program was substantially as described in the previous memorandum. Including military personnel, it involved a total of approximately 200 men. In view of the circumstances, that the test was carried out on a very tight time schedule and is to be regarded as a trial run, the organization functioned with considerable success.

The tightness of the schedule was affected by delays in procurement and transportation. This meant that some apparatus arrived only at the last moment, and involved feverish night work for many persons on one or more nights preceding that of the actual test. It is hoped to cure this in the final test, (a) by a more realistic scheduling allowing for time delays in procurement, (b) by the provision of additional transportation, part of which will be assigned to individual groups who will then be responsible for its upkeep, (c) by improvements in key roads which will reduce transportation breakdown, and (d) by the setting of a definite date, sufficiently in advance of the test, beyond which further apparatus cannot be introduced into the experimental area.

In connection with scheduling, it should be remarked that the tightness of the time schedule for this preliminary test has the advantages of emphasizing the need for a less hurried procedure in the final test, and of providing a longer interval of time to prepare for the final test.

There was some criticism in connection with arrangements for intercommunication and timing. Radio-communication was often weak

and subject to interference. It is planned to cure this by installing more telephone communication, by obtaining better radio sets, and if possible by obtaining more than a single radio frequency for use. The arrangements for sending time signals to various apparatus stations actually worked well but involved a large amount of last-minute work by an emergency group. It is possible that a separate group TR-7 will be set up to take charge of radio, telephone, and timing problems.

The organization is a temporary one set up specially for the Trinity Tests and involves the placing of heavy responsibilities on younger men, including SED members. This means a certain looseness in the organization, and inexperience on the part of some of the operators. In spite of this, the organization functioned as well as could be expected, and has now been through a good shakedown preparatory to the final test.

We may now turn to a brief but more detailed description of the different measurements and observations that were made, using the same headings as in the previous memorandum.

2.3-5 Behaviour of the Implosion

a. Detonator Simultaneity. No measurements of detonator simultaneity were made in this test.

Such measurements are standard at Los Alamos and Kingman.

b. Time Interval between Detonator and Nuclear Action. No measurements of time between detonator and nuclear action were possible.

c. Determination of α for the Nuclear Reaction. The cable and recording apparatus to be used by Wilson in the measurement of α were tested for "cross talk." The accidental signal level was a few millivolts so that the final apparatus will be designed to give its true signal at a level of about one volt.

2.3-6 Nuclear Energy Released

a. Delayed Neutrons. The equipment of Williams for measuring delayed neutrons was installed at a "scaled-in" distance and suffered no damage.

b. Delayed Gamma Rays. The apparatus of Moon for measuring delayed gamma rays was installed and gave records. Tests were made on equipment for Segre's method which withstood air blast and earth shock.

c. Conversion of 49 to Fission Products.

A distribution formula for the activity as a function of distance was determined. It was also determined that the local distribution in the soil was such as to permit alpha particle counts without difficult chemical separation. The rocket method for obtaining soil samples from the crater was tested

and found satisfactory, and the use of shielded tanks in connection with the final sampling was also tested.

2.3-7 Damage Effects Produced

a. Blast Pressure at Ground Level from Piezo Gauges. Eleven quartz blast gauges were installed and nine records obtained. These have not yet been analyzed in detail. Some of them show cross talk, but a certain amount of reliable data will certainly be obtained.

b. Blast Pressure at Ground Level from Condenser Gauges. Eight condenser gauges were planned for use, but only one actually was installed and it gave no record. In view of the success of a similar airborne gauge, some success in the final test is to be expected.

c. Blast Pressure at Ground Level from Excess Velocity. Six receivers were installed to pick up the blast wave and record its time of arrival. These worked well on the small calibration shot but gave evidence of much "cross talk" hash on the main shot. It is not yet known whether the records can be satisfactorily analyzed. Improvement might be introduced by lowered sensitivity for the main shot as compared with that needed for the calibration shot, and by leading the signals into separated rather than a single amplifier.

Forty-seven flash bombs to be operated by arrival of the blast were installed. Photographic observation was then to be used to determine blast pressure from excess velocity. Only two flash bombs went off due to personnel failure to provide enough batteries.

d. Peak Pressure at Ground Level from Paper Gauges. Twenty-nine box gauges, each with twelve holes covered with aluminum foil, were introduced to measure peak pressures at different distances, and functioned successfully.

e. Blast Impulse at Ground Level from Piston Acting on Fluid. Five instruments of Los Alamos design were planned, and one satisfactorily installed, for measuring blast impulse by following the action of a piston in forcing water through a set of constrictions. A good record was obtained but without timing marks; it can probably be analyzed as a consequence of the constancy of speed of the motor used to drive the recording disk. One instrument of British design did not operate entirely satisfactorily, perhaps from sand in the bearings, since it showed a velocity which increased during the passage of the blast wave.

f. Blast Pressure at Higher Levels from Condenser Gauges. Three condenser gauges for measuring blast pressure were dropped over the target from a height above ground of 15,000 feet by the observation plane. One radio receiver in the plane was known to be out of order from a fire, and one recording instrument failed. The other gave an excellent pressure time record. The three parachutes had to be dropped in salvo instead of successively as planned owing to failure in bomb release mechanism. The plane used was a B-29 assigned to the project. Hardly any shock was felt by the plane when the blast wave reached it at a distance of about four miles.

g. Earth Shock. Six converted geophones were used for

measuring velocities of earth motion and gave satisfactory records, which have not yet been analyzed. Survey is now being made to determine the permanent displacement of stakes driven into the ground around the point of explosion. The crater was about 5 feet deep and 30 feet in diameter which was smaller than expected. This may be partly due to the effect of the heavy concrete footing for the tower.

2.3-8. Overall Behaviour of the Explosion and Its After Effects

a. Size, Shape, Behaviour and Path of the Ball of Fire. Three out of three Fastax cameras (1000 frames per second) at 800 yards, and two out of two at 10,000 yards, operated satisfactorily. Two Mitchell cameras at 10,000 yards operated satisfactorily, one for 30 seconds and the other for the full 1000 seconds planned. Films have been sent out for development.

b. Radiation and Temperature of Ball of Fire. Two out of two Hilger spectrographs were in operation; there was some uncertainty about the focussing of one of these. The films are being developed. The Bausch & Lomb spectrograph, and the movie camera with filters were on low priority for this test and were not installed. The drum camera with photocells gave no record because of "cross-talk". The thermocouples and galvanometers appeared to function satisfactorily.

c. Behaviour of Hot Column. Three Fairchild Aero Cameras were installed. The two at 10,000 yards north and south did not operate because of personnel failing to push the necessary buttons. The one at 35,000 yards continued to take pictures until 9:00 A.M.

d. Mach Wave and Air Velocity. The proposed photographs of a suspended primacord were not obtained owing to failure to get the balloons up from which it was to be suspended due to poor quality balloons which burst and low helium supply. Photographs of a horizontal stretch of primacord appear to have been obtained. The primacord detonation was dimmed rather than brightened by the blast.

2.3-9 Meteorological Observations

Meteorological observations are being continuously undertaken to obtain a good idea of behaviour in the particular location. They would be greatly assisted by the proposed installation of a teletype weather service which has still not come through.

In connection with the present test, excellent meteorological service was provided. On 23 April it was successfully forecast that 7 May would fall in a good weather period. On 3 May, successful forecast was made as to the surface wind direction, upper air flow and visibility to be expected at 4:00 A.M. on 7 May. Similar forecasts were made on 5 May, and at 5:00 P.M. 6 May which gave 4:00 A.M. and also 9:00 to 10:30 A.M. as operationally possible.

Temperature, humidity and wind velocities at all levels up to 30,000 feet were measured with the help of radiosondes and radar at 1:30 A.M., 3:00 A.M. and 4:37 A.M., on 7 May, before and just after the explosion.

P. E. Church arrived in time for the test and was helpful in discussing meteorological methods and problems.

2.3-10 Health Control

Radioactive monitoring was carried out by Hempelmann during the processes of slug solution and introduction into the pile. Monitoring after the explosion in the neighborhood was carried out by Hempelmann and checked by Anderson. The level of activity in the final crater was low enough to be safe for several hours exposure.

The dissolving unit is to be covered with fresh earth and surrounded by a guard fence.

2.3-11 Conclusion

The test appears to me to have been successful as a trial run. In the final test, it is to be hoped that a larger proportion of the measurements will be successful, but even if this were not the case sufficient data would be provided to answer a considerable proportion of the necessary questions.

There is common agreement, among those concerned, as to the steps suggested which should be taken to insure greater success in the final test. Among these suggestions, one of the most important is that of setting an advance date beyond which further apparatus, especially electrical apparatus, cannot be introduced into the experimental area. This will allow time for plenty of dry runs, and elimination of "cross-talk". Improvement in transportation equipment and key roads should be sought. Special attention should be given to the early procurement and testing of those very important kinds of apparatus that could not be tried in the present partial test.

POST 100 TON

SUGGESTIONS FOR IMPROVED FACILITIES AND PROCEDURE

2.4 SUGGESTIONS FOR IMPROVEMENTS

A few days after the shot while the experiences of the personnel were still fresh in peoples' minds, Bainbridge called a meeting in which all gripes could be aired and suggestions made for improved operating procedure. Written suggestions from J. E. Mack and from members of J. H. Manley's group were particularly valuable.

The 100 ton test pointed up the following requirements:

(1) Better roads were needed to protect personnel and instruments from the effects of dust...essential to meet the schedule.

About twenty miles of black top road were laid, and an area in the vicinity of the tower.

(2) More vehicles were required per group. Additional cars, weapons carriers and carryalls were obtained by purchase or loan to help in correcting the deficit, but there was never a surplus.

Thanks to the continued hard work of D. Greene and emergency loans from Major Miller, the transportation problem was licked. The final list of vehicles comprised approximately

15	Sedans
16	Weapons Carriers
32	Carryalls
11	Jeeps

to which possibly 30 more cars were added the last week by the monitoring and G-2 groups.

(3) More repair men were needed and night servicing was required to aid in keeping up with the vehicle demand.

Arrangements were made with Major Stevens and Capt. Davalos for additional help. The car parking and checking system set up by Greene and the improved roads aided in decreasing the amount of repair work per car.

(4) Wire communications were overloaded so that plans were made for more telephone lines, address systems in all shelters, and more Motorola radios in field cars and at shelters.

The telephone system later installed by Lt. Comdr. T. M. Keiller of J. H. Williams' group is described in TR Circular No. 12 (see appendix Ser. No. 17).

Eighteen vehicles were equipped with 25 watt Motorola FM radios. Their convenience was great and more could have been used with profit, possibly an additional ten before the radio traffic became congested.

(5) The need for additional help on procurement, shipping, and stock management at Trinity could be anticipated with the scheduled increased activity for the July shot.

A teletype was installed for "in the clear" communication between Y and TR. More stock men at TR and longer hours open schedules were used at Fubar Stockroom. D.P.Mitchell was able to furnish alternates or "stand-ins" for key men such as Van Gemert and Harry Allen at Y so that the absence of one or the other on other work for a short time would not slow down the solution of Trinity problems.

(6) A Town Hall was finally built at Trinity so that the regular nightly meetings on construction and occasional technical meetings or administrative meetings could be properly housed. The ranch house office furnished a central point for mail and bulletins of general interest.

(7) The hardness of the water at Trinity made it difficult to maintain ordinary sanitary requirements in the mess hall.

A water softening equipment was installed but some error occurred in the analysis of a sample of typical water so that the unit was entirely too small to handle the gypsum and lime content encountered.

The addition of a steam bath for trays solved the grease and sanitary problems. More help in the mess hall was finally obtained so that 18 hour working days were no longer the rule for the chefs and KP help.

(8) The guarding rules during the 12 hours preceding the shot were too rigid.

A nose counting system had been set up so that everyone could be accounted for two hours before the shot until after the shot. Emergencies arose in which an electronics expert, for example, would have to proceed from the S-10,000 to the N-10,000 yard shelter at -2-1/2 hours. As he had not been on the N-10,000 guard's list, some telephoning was required before he could be admitted. Considerable time was wasted in emergencies of this sort or because other trips of personnel had not been anticipated fully.

In the final arrangement for July 12 and succeeding rehearsals, and just prior to the July 16 shot, ANYONE having legitmate business outside of the Base Camp had free access to all parts of the test area. Free access was feasible as by mutual agreement each respected the others' problems, wiring troubles and need for unhampered work in getting the job done. As a matter of safety, everyone was asked not to kibitz at the tower during assembly, hoisting, checking, cooking, i.e., any time after assembly started.

2.5 CONCLUSIONS CONCERNING THE 100 TON TEST

The original purposes for which the 100 ton test had been planned were accomplished. Those who had no prior experience in field work were familiarized with the difficulties and tribulations associated with work away from a well-equipped laboratory. The atomic bomb test could be approached with more confidence after the shake-down test. The calibration of instruments was valuable, particularly for blast measurements, where the 100 ton data furnished a useful calibration point of greater value than extrapolation from tables prepared from 66 lb. shots. The earth shock data

gave a reference point which was greatly superior to extrapolations from various short range laws which varied in their predictions for large ranges over tremendous factors. The design of shock-proof instrument shelters could proceed with confidence. The gaps in equipment and organization pointed out by the test could be corrected or plans altered to give a smoother operation in the main show.

The high percentage of successful measurements in the final July 16 test may be attributed in large measure to the May 7 rehearsal shot practice which gave an improved framework on which to build.

CHAPTER 3

PREPARATIONS FOR THE JULY 16 TEST

3.0 INTRODUCTION

The preparations for the bomb test were greatly increased in intensity starting in March, when a July 4 date was set for the gadget test.[1] In the final two weeks about 250 men from Y were engaged in technical work at Trinity and many more contributed to theoretical and experimental studies at Y, and in the construction of equipment. The very difficult work of providing in time the wiring, power, transportation, communication facilities and construction needed for the test was ably carried out by J. H. Williams and his group. The whole-hearted support of other groups in Project Y made the test possible. In addition to the work of R-1, R-2, R-3, R-4, F-4, G-11 and O-4, which groups had effectively transferred full time into the Trinity Project, Groups T-3 under Weisskopf and T-7 under Hirschfelder gave full time to the consideration of nuclear and radiation effects or to damage phenomena which would be associated with a successful shot. R. F. Bacher generously gave the support of G Division by the loan of personnel or by supplying special equipment for the test preparations. Heavy demands were made upon W. A. Higinbotham's Group G-4. He assigned his best personnel to stratetic points and his group manufactured the greater part of the electronic amplifying and recording equipment and all of the main electronic timing equipment. The very important and punishing

[1] The Cowpuncher Committee finally agreed (June 30) on July 16 for the earliest possible date.

job of supplying the timing and remote operating signals was well done by J. L. McKibben for the relay and safing circuits and by E. W. Titterton for the electronic timing and detonating circuits.

3.1 ORGANIZATION

The detailed organization chart must be included here to be read as it gives the most concise view of the responsibilities and number of people necessary for the conduct of a test. In many cases an individual took part in the preparation of several experiments and went from one job to another as required. The list given conforms to the situation the last week or possibly two weeks leading up to the test. For the period four weeks prior to the test only two-thirds to three-fourths of the people listed were engaged full time, and only one-half for the four months prior.

ORGANIZATION CHART FOR PROJECT TR

K. T. Bainbridge	Administrative head. Over-all responsibility. Veto power on suggested experiments. Planning and coordination. Arming Party.
Barbara S. Anderson	Secretary
J. H. Williams (TR-1)	All services as given under TR-1 below. Alternate for Bainbridge.
F. Oppenheimer	Administrative aide. Planning. Safety. Emergency roving center.
Lt. H. C. Bush	Commanding Officer of Trinity Camp. Responsible for camp matters, barracks, mess, road maintenance, guarding, camp hygiene, etc. Arming Party.
Lt. R. A. Taylor	Security for Trinity at Y
John Anderson	Security for Trinity at TR

Capt. S. P. Davalos Lt. R. D. Wholey	(TR U.S. Engineer Detachment Operations (U.S. Army Contracts
Sgt. W. Stewart	Responsible for H.E. for all instrument calibration tests, velocity of sound charges, etc. Arming Party.

Consultants

R. W. Carlson (X-2)	Design of structures. Installation of tower.
P. E. Church	Meteorological problems, particularly the dilution of active gases.
E. Fermi (F Division)	All nuclear physics measurements.
J. O. Hirschfelder (T-7)	All problems affecting damage which arises after the nuclear reactions have stopped.
S. Kershaw	Proper safety regulations and procedures.
L. D. Leet	Earth shock problems particularly at distant points.
W. G. Penney	Blast, earth shock and permanent earth displacement problems.
Ens. G. T. Reynolds	Structures.
V. Weisskopf	All nuclear physics measurements and radiation problems. Chairman of Nuclear Measurements Committee.

TR ASSEMBLY — All problems connected with assembly of the gadget

Comdr. N. E. Bradbury (X-1, X-6) Head
G. B. Kistiakowsky, Alternate Arming Party

Pit Assembly (G-1)

M. G. Holloway P. Morrison	Pit Assembly over-all responsibility
R. F. Bacher	Advisor
R. E. Schreiber H. K. Daghlian	Certification

Pit Assembly (G-1) (cont)

L. Slotin B. D. McDaniel C. S. Smith	Mechanical Assembly (check later on tower)
M. G. Holloway	Mechanical Assembly at base of tower (check later on tower)
L. Slotin H. K. Daghlian	Monitoring
B. T. Feld	Checking
Sgt. H. Lehr	Assembly

Detonator Unit (X-5)

D. F. Hornig T/4 R. J. Brown T/3 W. Vogel	Raytheon unit. Wiring of detonators. Test of stand-in unit.

Asimultaneity (X-7)

K. Greisen J. C. Anderson T/3 V. Caleca R. W. Williams	Installation and check of special switches and circuits. E.W.Titterton on recording mechanism at W-800. Testing of H.E.-actuated switches.

H.E.Assembly and Detonators (X Division)

R. S. Warner, Jr. R. W. Henderson H. Linschitz Lt. W. F. Schaffer T/3 L. Jercinovic A. B. Machen T/3 A. D. Van Vessem E. J. Lofgren	H.E. and mechanical assembly. Installation of detonators. Test of detonators.

TR-1 J. H. Williams (R-2)	Services
TR-1A Lt.Comdr.T.M.Keiller, Head	Construction
T/4 A. H. Jopp, Supv.	Electrical construction & telephone services
Pvt. A. L. Brehm, Supv. Pvt. L. Jackson Pvt. V. Guess T/5 J. Mather T/4 S. Friedman Pvt. B. Doyle T/5 A. Martinez	Motor generators

TR-1B	J. L. McKibben, Head	Timing, all timing and remote control signals. Arming Party.
	T/3 W. Treibel	
	Pfc. R. Moore	
	R. Perry	
	C. L. Bailey	(Later searchlight group)
	L. Guttman	
	E. W. Titterton	Electronic time signals
	T/3 V. Fitch	
	T/3 R. Lowry	
	G. Mathis	
	C. R. Linton	
TR-1C	R. J. Van Gemert, Head	Procurement at Y
	T/5 T. Montgomery	Stock
	T/5 E. Percy	"
	T/5 C. Pettis	Y Shipping to S-45 (TR)
	Additional unloaders and clerks	
TR-1D	D. Greene, Head	Transportation at TR
	1 SED to assist Greene	
	Sgt. Margaret Swank, Head	" at Y
TR-1E	F. Stokes, Head	Radio Communications
	T/3 G. Curl	
	T/4 D. Miller	SCR-299 at S-10,000 #1 unit
	T/5 A. Giordano	SCR-299 at S-10,000 #2 unit
	Pvt. R. B. Hart	
	Pvt. W. D. Braden	
TR-1F	Capt. B. B. Geery	Balloon Flying
	Pvt. G. Merrigan	
	Pvt. A. W. Reinert	
TR-1G	H. S. Allen	High iron work and special jobs
	T/5 A. Newell	
	T/4 E. Utzig	
	T/4 J. A. Rice	
	W. Case	
TR-2	J. H. Manley (R-3)	Air Blast and Earth Shock - Responsible for all measurements below in TR-2 group.
	W. G. Penney, Consultant	
	H. H. Barschall, 1st Alt.	
	T. Jorgensen, 2nd Alternate	

Air Blast

TR-2A R. L. Walker — Piezo Gauges
H. Sheard, Consultant
D. Littler "
W. D. Kennedy "
R. Babick (from A-1)
T/3 M. Battat
T/4 H. Courant
E. Lennox
W. Nyer
M. Sands (from G-4)
Pfc. C. Simons (from CM-13)

TR-2B W. C. Bright — Condenser Gauges
V. Anderson
T/4 R. Dye (from G-4)
W. Hane (from G-4)
T/4 K. Kupferberg
T/4 D. Leed (from G-4)
F. Olivas

TR-2C H. H. Barschall — Excess Velocity Measurement
R. W. Davis
W. Elmore (from G-4)
G. M. Martin

TR-2D T. Jorgensen — Impulse Gauge
Pvt. D. W. Rhoades
R. Sherr

TR-2E H. Sheard, D. Littler — Maximum Pressure Gauge
C. Janney
W. Lawrence

TR-2F J. C. Hoogterp — Box Gauge
Pfc. F. Michaels

Earth Shock

L. D. Leet, Consultant

TR-2G H. M. Houghton — Velocity Geophone
J. Coon, Alternate
Pvt. C. D. Jones
R. Nobles
T/5 O. Seborer

TR-2H L. D. Leet — Displacement Seismographs (Tularosa)
H. Gewertz, Alternate — 9000 N
J. A. Crocker — 9000 N
T/3 A. Hershey — Elephant Butte
T/5 D. Garrett — Elephant Butte
T/3 C. Crumb — San Antonio
T/4 J. Lepman — San Antonio
T/4 S. Calvert — Tularosa
Elizabeth R. Graves — Carrizozo
A. C. Graves — Carrizozo
Pfc. G. Hall

TR-2I W. G. Penney — Permanent Earth Displacement
W. G. Marley
F. Reines
Surveyors

TR-3 R. R. Wilson (R Div.) — Physics
E. Fermi, Consultant
V. Weisskopf, Consultant

TR-3A R. R. Wilson (R-1) — Prompt Measurements: α and shock wave transmission time (shock wave transmission time - Froman at Y)
J. DeWire, Alternate
S. Barnes
H. Bridge
W. Caldes
P. Balch
T/5 R. Fortenbaugh
T/5 W. S. Hall
L. Lavatelli
W. Schaefer
T. Snyder
R. Sutton
W. Woodward

B. Rossi, Consultant & Head — Prompt Measurements: α. Cooperating with R-1 on M.I.T. fast oscillograph
T/4 J. Alexander
J. Allen
B. Diven
J. Fox
J. Fredricks
A. Grubman
S. A. Kline
C. Menz
D. Nicodemus
Corp. R. E. Sherman

TR-3B	H. T. Richards	Delayed Neutron Measurements
	J. M. Blair	
	D. Frisch	
	J. Hush	
	E. Klema	
	R. Krohn	
	R. Perry	
	C. Turner	
TR-3C	E. Segre (R-4)	Delayed Gamma Rays
	C. Wiegand	Electrical part
	M. Deutsch	Ionization chambers & calibrations
	O. Chamberlain	Shelter design
	J. Aeby	
	G. W. Farwell	
	G. A. Linenberger	
	W. Nobles	
	T/4 A. H. Spano	
	T/5 C. Wahlig	
TR-3D	P. B. Moon	Gamma Ray Sentinels and Delayed Gamma Rays
	S/Sgt. W. J. Breiter	
	Ens. I. Halpern	
	T/4 J. A. Hofmann	
	J. Hughes	
	T/5 M. J. Pincus	
TR-3E	H. L. Anderson (F-4)	Conversion
	C. W. Snyder	C.I.T. Rocket Consultant
	G. L. Weil	Rocket Sampling
	D. E. Nagle	Tank Sampling
	H. Heskett	
	Sgt. J. Twombly	Radio Maintenance
	Sgt. N. Smith	Tank Driver
	Sgt. J. Brothers	" "
	T/5 F. J. Tucci	Tank Maintenance
	Sgt. G. Banas	" "
	L. D. P. King	Survey
	A. Turkevich	
	V. Cannon	Gross Counting
	N. Wilkening	Alpha Counting
	J. Tabin	Beta Counting
	A. Novick	Gamma Counting

TR-3E (cont.)
N. Sugarman — Chemistry
D. Engelkemeir — 49 Chemistry
M. Kahn
J. Miskell

S. Katcoff — Fission Product Chemistry
J. Seiler
L. Winsberg

Sgt. C. Schwob — Sampling at Y
Sgt. E. Hoagland

A. Goldstein — Counting Room at Y
WAC Technicians
M. Young
M. Wirz
S. Lozier
S. Corl

TR-4 J. M. Hubbard — <u>Meteorology</u>

TR-4A Lt. C. D. Curtis — Radar
Pvt. F. K. France
T/5 T. Harlowe
Pvt. R. L. Heller
Pvt. G. F. Mason
Pvt. G. Meyers

TR-4B Sgt. J. G. Alderson — Pilot Balloons (Arming Party)
Sgt. J. M. Lobel
Sgt. J. G. Taylor

TR-4C Sgt. P. A. Tudor — Radiosonde
Sgt. L. Caskey
Sgt. I. E. Rosenthal

TR-4D Sgt. W. Blades — Base Weather and Records

TR-5 J. E. Mack (G-11) — <u>Spectrographic and Photographic Meas.</u>
B. Brixner, Alternate
N. Bifano, Alternate at Y
T/3 N. York (permanently at TR & in charge in absence of Mack & Brixner)
T/5 E. D. Wallis — Photographer (and stockkeeper until Shue's arrival)

T/4 B. C. Benjamin
T/5 G. E. Economou
F. E. Geiger
R. Loevinger
T. S. Needels
T/5 K. J. Shue — Stockkeeper
T/3 G. W. Thompson — Photographer
T/4 J. Wahlen — Wiring Liaison

TR-5 (cont.)

D. Williams	Total Radiation
P. Yuster	

TR-6 B. Waldman (O-2)	<u>Air Blast - Airborne Condenser Gauges</u>
L. Alvarez	
H. Agnew	
R. Dike	
T/5 R. Alhbrand	
T/5 W. Goodman	
L. Johnston	
T/3 E. Karas	
T/3 J. Wieboldt	
W. Stroud	

TR-7 Dr. L. H. Hempelmann	<u>Medical Group</u>
Capt. J. F. Nolan, Head at TR	
Col. S. L. Warren, Consultant	
J. Hoffman, Consultant	

TR-7A R. Watts	Instruments
W. Scivally	
L. Brown	

TR-7B P. Aebersold	Monitor Group
Capt. H. L. Barnett	N-10,000
Lt. J. H. Allen	W-10,000
Capt. P. O. Hageman	S-10,000
A. Anderson	Road Monitors
Sgt. J. Green	
J. O. Hirschfelder	
J. Hoffman	
Sgt. R. Leonard	
Sgt. P. Levine	
J. Magee	
Lt. J. S. Brooks	Emergency Medical Aid
Lt. A. M. Large	

<u>Special Assignments</u>

Capt. M. Allen	Searchlight Plotting
L. Reiser, Assistant	
Pvt. J. H. Fuqua	L-2 crew at W-10,000
Paul Hough	
T/5 C. Wright	
C. L. Bailey	L-3 crew at N-10,000
D. Barton	
T/5 D. Miller	

Special Assignments (cont.)

A. Breslow I. Rehn R. White	L-7 crew NE of O
J. Blair M. Kupferberg A. Nedzel	L-8 crew NNE of O
S. K. Allison	Ground-to-plane communication and shelter announcer
Col. D. M. Yates Col. B. Holzman	Weather consultants to Gen. Farrell
J. Mattingly	Meteorological observer for P.E. Church and consultant on dilution problems

A total of 125 men were under Lt. H. C. Bush's command charged with the responsibility of guarding and maintaining the camp.

An additional 160 men were located north of the test area under the command of Major T. O. Palmer with sufficient vehicles to be able to evacuate ranches and towns if the products descended in dangerous amounts.

At least 20 men associated with the Military Intelligence were in neighboring towns and cities up to 100 miles away. Eighteen were provided with recording barographs as described in LA-360 (appendix Ser. No. 42). These instruments and the remote seismographs were for the purpose of getting permanent records of blast and earth shock at remote points and in neighboring towns.

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Distinguished Visitors, July 10-16

J. R. Oppenheimer
R. C. Tolman
V. Bush
J. B. Conant
Brig. Gen T. F. Farrell
Maj. Gen. L. R. Groves
C. C. Lauritsen
I. I. Rabi
Sir Geoffrey I. Taylor
Sir James Chadwick

3.2 COORDINATION OF PREPARATIONS

3.2-1 Consultants

The advice and predictions of V. Weisskopf on the behaviour of the gadget and its radiation effects, of J. H. Manley and W. G. Penney on shock and blast effects, and J. O. Hirschfelder on post-shot phenomena were of the greatest importance in defining the operations at Trinity and their preparation. R. W. Carlson and Ens. G. T. Reynolds aided in advising on structures and blast phenomena.

Major contributions and aid also were frequently furnished by H. A. Bethe, E. Fermi and J. R. Oppenheimer.

The comprehensive reports which guided the preparations are:

	Title	Author	Doc.Rm No.	Appendix Ser. No.
I.	Neutron and Gamma Ray Effects After the Nuclear Explosion - I	V. Weisskopf	LAMS-218	9
	Same - II	V. Weisskopf	LAMS-250	10
	Same-Correction	V. Weisskopf	LAMS-250-A	10A

The final study in which actual July 16 records are introduced is given in Chapter 6 of this volume: "The Radial Distribution of Gamma-ray, Neutron, and Heat Irradiation in the July 16, 1945 Test" by John L. Magee.

UNCLASSIFIED

Title	Author	Doc. Rm. No.	Appendix Ser. No.
II. Ground Shock Resulting from Detonations on or above the Surface	Ens. G. T. Reynolds	LAMS-226	11
The Motion of Earth Thrown from Small Craters by Explosive Charges	D. P. MacMillan H. A. Wilcox	LA-292	70
III. Estimated Maximum Pressures, Positive Impulses and Positive Duration in the Blast from Very Large Bare Charges of TNT	W. D. Kennedy D. J. Littler H. Sheard	LAMS-247	12
Estimated Blast Pressures from TNT Charges of 2 to 10,000 Tons	J. O. Hirschfelder D. J. Littler H. Sheard	LA-316	13
IV. Blast Radiation Ball of Fire	J. O. Hirschfelder	LAMS-221 pp. 24-31	14
Characteristics of the Hot-Air Column Produced by a Gadget Explosion	J. O. Hirschfelder	LA-270	15
V. Fate of Active Material	J. O. Hirschfelder J. Magee	Parts of LAMS-277	56

Most of the material in these reports had been made available by the authors to the interested group and section leaders weeks before the actual dates of publication.

3.2-2 Weekly Meetings

One or two hour meetings were held every week for consideration of new experiments, correlation of work, detailed scheduling and progress reports.

The members who regularly attended were the Consultants, Group and Section Leaders who held great responsibilities in the test and preparations for it. The members were:

K. T. Bainbridge	Chairman
H. L. Anderson	TR-3E Conversion Measurements
H. H. Barschall	TR-2 Alternate Group Leader
E. Fermi	Consultant on Nuclear Physics problems
L. H. Hempelmann	TR-7 Medical problems
J. M. Hubbard	TR-4 Meteorology
Lt. Comdr. T. M. Keiller	TR-1A Construction and Electrical services
J. E. Mack	TR-5 Spectrographic and Photographic meas.
J. H. Manley	TR-2 Shock and Blast
J. L. McKibben	TR-1B Timing services
F. Oppenheimer	TR Administrative and Technical Aide
W. G. Penney	Consultant, Shock and Blast
H. T. Richards	TR-3B Delayed Neutron measurements
E. Segre	TR-3C Delayed Gamma Ray measurements
E. W. Titterton	TR-1B Electronic Timing services
B. Waldman	TR-6 Airborne measurements
V. Weisskopf	Consultant on Nuclear Physics
J. H. Williams	TR-1 Services
R. R. Wilson	TR-3 Physics measurements

The minutes of the meetings are appended, Ser. No. 16.

3.2-3 <u>Acceptance of New Experiments</u>

It was essential to get the most out of the test and to meet the date which required that all proposed experiments should be studied critically. If a new experiment was approved by the designated examining group it was presented before the Monday meeting for consideration with respect to the program as a whole.

The first examining groups were:

J. H. Manley and W. G. Penney	Blast and Earth Shock
R. R. Wilson, E. Fermi, V. Weisskopf	Nuclear Measurements
J. E. Mack, V. Weisskopf	Spectrographic and Photographic Measurements
B. Waldman and appropriate consultant	Airborne Measurements

and K. T. Bainbridge served ex-officio on all examining groups.

It was also essential that the proponent should carry out his plans on paper far enough so that the proposal would appear

in its right size, shape and degree of complexity. One must know how much will be involved if the proposed experiment should be included in the program.

The following minimum requirements were set which had to be answered before the proposal could be considered at a Monday meeting:

(1) Object or relationship to energy release, damage, etc.

(2) Estimates of accuracy expected, calibrations needed.

(3) Number and recommended positions of gauges, chambers.

(4) Position of recorders, type of recorders, availability of recorders.

(5) Design and location of recorder chambers, amount of shielding, date needed for completion in place ready for occupation.

(6) Signal lines required and type.

(7) Actuating, timing, calibrating lines needed.

(8) Timing signals and allowed probable variation acceptable.

(9) Estimate of number of men required at site for installation, and names if possible.

(10) Personnel, if any, required at the time of the shot who will have to be in recorder shelters W-10,000, S-10,000 or N-10,000.

(11) Machine shop construction time, checked by E. Long or G. Schultz.

(12) Electronics development time, checked by W. Higinbotham, particularly if it involves key circuit designers.

(13) Electronics shop time not involving development by key circuit designers.

With the above information at hand a satisfactory picture was presented of just how much a new experiment involved so that a decision could be reached rapidly on its suitability for the program

and the possibilities of its successful completion in view of the test schedule and the laboratory limitations on machine shop and electronics time.

3.2-4 Prompt Dissemination of General Information

The large number of personnel of many groups with responsibilities in the test made it mandatory that all information of general usefulness should be circularized. The early suggestion of J. H. Williams that this circularization should be done saved time for all concerned and was indeed the only way in which one could be sure of complete coverage.

The Project TR circulars are included in the appendix (Ser. No. 17) as they give a picture of the project and the problems associated with it, and its growth, which serve to supplement the body of this report.

The associated circulars sent only to TR personnel are appended (Ser. No. 18). These deal specifically with the arrangements for the July 16 shot:

	Appendix Ser. No.
Wiring, Timing, Space, Men, Vehicles, Equipment Requirements for Gadget Shot	18-A
Shop Time for Project TR	18-B
Tower Construction and Gadget Assembly Schedules	18-C
Procurement of Critical Items	18-D
Arrangements for Leet's Seismographs	18-E
List of People Who Will Have to Enter Contaminated Area After the Shot	18-F
Space Assignments in Shelters at t = 0	18-G

3.2-5 Coordination of Construction

Approximately one month prior to the July 16th shot and during a similar period before the May 7 shot, J. H. Williams held nightly meetings to hear reports on field construction progress and to plan the assignment of men for the following day. As finally developed J.H.Williams with J. L. McKibben, Lt. Comdr. Keiller, Sgt. Jopp and F. Stokes would meet directly after supper with Capt. S. P. Davalos or Sgt. Gibson, representing the Engineer Detachment, and all interested group or section leaders who had field construction work under way. Construction help was assigned based on the needs and priority of the experiments which had been accepted for the test.

The correlation of the construction program and the proper and successful designation of construction aid was exacting work requiring "superior judgment", as the Army says, and long hours of hard work. This was done supremely well by J. H. Williams, to whom the TR Project owes much for the successful completion of the operation of July 16.

CHAPTER 4

FINAL PREPARATIONS FOR REHEARSALS, AND TEST

4.1 SCHEDULE

During the period from June 9 to June 30 the test date was set for July 13 with a first rehearsal July 8. This fixed the schedules for everyone participating in the Trinity test. S. K. Allison as chairman of the Cowpuncher Committee had the responsibility of integrating the efforts of the entire Project Y and the receipt of material from Hanford.

On June 30 a review was made of all schedules at the Cowpuncher Committee meeting where all division leaders submitted the earliest possible date at which their work could be ready. The earliest date for the Trinity shot was changed to July 16 as required for the inclusion of some of the more important experiments and the same date followed from X Division considerations on June 30. (Later it was found that their schedule for assembly was more conservative than was proven by the actual work so that a day was shaved from their schedule, which could not be taken advantage of by the TR group and indeed was not even mentioned to them, as the TR schedule was tight enough on a July 16 basis.)

Commitments had been made in Washington for the test as soon after July 15 as possible, which was accomplished by firing the shot the morning of July 16 at the first instant weather conditions were at all suitable. The predictions of J. M. Hubbard were for more nearly ideal weather on the 18th or 19th, with July 16 only a possible date.

The schedule which was broadcast July 1 and circulated July 3 is given below. The afternoon rehearsals had to be changed to morning rehearsals as the daily afternoon thunderstorms interfered with the flight of the B-29 planes cooperating in the test and also produced electrical interference and pick-up on lines. The second rehearsal was held the late morning of July 12 and the third the late morning of July 13, with the final rehearsal held at 11:59 P.M. the evening of the 14th. The complete announcement is in TR Circular No. 19 included in Ser. No. 17 of the appendix.

TR SCHEDULE

The earliest date is July 16 4:00 A.M.

Date	Time	All Circuits	V-Sound 5# Chg.	Gadget 1/2# Chg.	Plane	Guards	Medical	G-2	Remote Seismo.
7/10	0400-0445								Radio test
7/11	1200 Freeze								
7/11	1600	x	x	x	x				
7/12	No test. Chase down pick-up troubles.								
7/13	1600	x	x	x	x				
7/14	2359	x	x	x	x	x	x	x	x
7/15	NO REHEARSAL								
7/16	0300)	THIS WILL BE IT IF WEATHER PERMITS							
7/17	0400)	x	x	x	x	x	x	x	x

ASSEMBLY RUNS

Dates for the "TR Dry Run" were set prior to June 30 and were adhered to. These were:

Monday, July 2	Load inert assembly on truck; test by driving around mess.
Tuesday, July 3	Truck leaves for TR at 0500; arrives TR sometime in afternoon. If during daylight, truck is unloaded at this time.
Wednesday, July 4	Unload truck (if not previously done) trap door, reassemble and lift. (Note that wiring people should be available for work by 1300 of this day for tower top operations.)
Thursday, July 5	Complete tower top wiring, disassemble and lower.
Friday, July 6	Unit returns to Y.

The complete schedule set by N. E. Bradbury is given in Ser. No. 19 of the appendix.

A summary of all the problems connected with the F.M. assembly is given by Capt. Schaffer in Chapter 5, together with the firm dates for the "TR Hot Run", with final assembly starting Friday, July 13, at 1300. A summary of the activities of the G-Eng. group in connection with the assembly is included in the appendix as Ser. No. 20.

4.2 TIMING AND WIRING LAYOUT - ELECTRONICS

The detailed location of measuring equipment is given on two maps in the appendix. Ser. Nos. 21 and 22. A complete list of the apparatus turned on by the control system is given in McKibben's report LA-435 (Ser. No. 23) to which reference should be made for details of the safety and indicating features incorporated in the control circuits to all equipment, and the firing circuits. Details of the electronic timing circuits and firing circuit are given in Titterton's report LA-436 (Ser. No. 24).

4.3 SHELTER CHIEFS

It worked out very well to have one senior man act as Shelter Chief at each of the three main shelters. The Shelter Chiefs:

(1) Are in charge of the technical personnel, military and civilian, with the exception of the M.P. guards. The Medical Officer is the alternate Shelter Chief;

(2) Are responsible for shelter discipline;

(3) Are responsible for the proper parking of vehicles in preparation for a quick exit and checking of vehicles prior to the shot to see that they have sufficient gasoline and oil;

(4) Are responsible for the assignment of personnel to vehicles;

(5) Will on the advice of the Medical Officer enforce the orderly evacuation of the shelter in the direction recommended by the Medical Officer, except for the radar, searchlight and optical crews at W-10,000 or N-10,000;

(a) The Shelter Chief will lead the convoy. The Medical Officer's assistant will take the last car in the convoy;

(b) At W-10,000 and N-10,000 where there are searchlight, optical crews (and a radar crew at W-10,000), the Medical Officer will remain with the units if no radiation is encountered until their work is completed and then will convoy them out as recommended by the senior Medical Officer at S-10,000 or by the local Medical Officer if communications are unsatisfactory;

(c) In the event of an emergency evacuation, the Shelter Chief will lead the convoy and the Medical Officer will take the

last car, after all personnel have been evacuated.

(6) Will aid the guard in checking personnel lists;

(7) Will post weather reports transmitted from S-10,000;

(8) Will check that all personnel are wearing respirators;

(9) Will check that the shelter doors are off and properly stacked against the wall.

In explanation of the evacuation rules it should be stated that if no fission products were encountered at the shelter proper, the searchlight, optical and radar crews were to remain to obtain data on the cloud position and continue with the planned plotting and photographic work. The other personnel required not more than 20 minutes to shut down equipment and extract photographic records. Then they were to leave either to the Base Camp or to Site Y and would be followed by the searchlight, optical and radar crews when their work was completed.

Because of the possibility of contamination on the roads, the Medical Officer was to define the routing, as he would receive the detailed information required to make a decision from the Base Camp headquarters and from the S-10,000 headquarters. The Shelter Chiefs were ordered to go first as they were most familiar with the roads in the country and the driving conditions. The Medical Officers were asked to go last with their monitoring equipment in accord with their responsibility for the health of the group.

In the event of radiation rising in the immediate vicinity of the shelter, all personnel were to be evacuated on an emergency

basis, as actually was required when a low cloud passed over N-10,000 without depositing much on the ground, as shown by measurements made approximately two hours later (< 0.02 R/hr.). The Shelter Chiefs and Medical Officers were R. R. Wilson and Capt. H. Barnett at N-10,000, J. H. Manley and Lt. J. H. Allen at W-10,000, F. Oppenheimer and Capt. P. O. Hageman at S-10,000.

4.4 ARMING PARTY

The arming party comprised

K. T. Bainbridge	Checked arming routine as responsible head
J. L. McKibben	In charge of timing and control circuits
G. B. Kistiakowsky	To check Bainbridge and McKibben in the arming operations. Aided Mack in focusing cameras and spectrographs by manipulating a portable searchlight at the first platform level on the tower.
Sgt. W. Stewart	Rigged the 5# Comp. B charge for the velocity of sound measurements
Sgt. J. C. Alderson	Responsible for getting weather data at Point O until withdrawal of the party
Lt. H. C. Bush and 1 guard	Lt. Bush took over from Lt. Richardson the responsibility for preventing sabotage of the bomb or its auxiliaries. The arming party did not withdraw until searchlights L-2 and L-3 were focussed on the tower to discourage any possible saboteur.

J. L. McKibben's check list with a few additions corresponding to actual operations is appended, Ser. No. 25.

The arming party remained at the base of the tower until just before 5:00 A.M. when the weather reports from Hubbard by phone began to look satisfactory for a shot. Sgt. Stewart was released to S-10,000 before 5:00 A.M. as his job had been completed. The

drive out to S-10,000 was not made above 35 mph, contrary to rumors. Original plans were for the entire party to return at 2:00 A.M. to S-10,000 where J. R. Oppenheimer, Gen. Farrell, J. M. Hubbard and K. T. Bainbridge would decide at t_0 - 1/2 hour whether or not the test should be run. One dissenting vote was sufficient to call off the shot. Sunday afternoon discussions of possible sabotage of the bomb made it reasonable for the arming party to guard the tower until the last possible moment.

The final OK for the shot was given at 5:10 A.M. for 5:30 A.M. as 20 minutes was needed for preparation in the three main shelters.

4.5 LOCATION AND TIME OF SHOT

The location of Point O was latitude 33°40'31", longitude 106°28'29", based on New Mexico Map #44, Grazing Service, Albuquerque Drafting Office.

The time is only known very poorly because of difficulty in picking up Station WWV for a time check. The best figure is July 16, 1945, 5:29:15 seconds A.M. MWT plus 20 seconds minus 5 seconds error spread.

4.6 PROTECTION AGAINST RADIATION - BASE CAMP

The following instructions were issued by Col. S. L. Warren dated 15 July 1945:

DIRECTIONS FOR PERSONNEL AT BASE CAMP AT TIME OF SHOT

1. Do not leave the main group at the camp where there will be monitoring and evacuation facilities. There will also be contact by radio with the planes, the shelters and area monitors.

2. No one should remain in camp who can view the show from the mountains to the north and then leave immediately for Site Y. A minimum number of vehicles should be taken away from camp.

3. Persons will not be permitted to leave along Broadway until all danger of contamination has passed and the monitors have declared it safe. This may take several hours.

4. We do not expect danger to the Base Camp, but all personnel will conform with the following safety regulations:

(a) At a short signal of the siren at minus (-) 5 minutes all personnel whose duties do not specifically require otherwise will prepare to face the south, looking in the direction parallel to the long axis of the barracks buildings.

(b) At a long signal of the siren at minus 2 minutes all personnel whose duties do not specifically require otherwise will lie prone on the ground or in an earthen depression, the face and eyes directed toward the south.

(c) After the south hills light up, one may look toward zero with the eyes covered by a welder's filter, which will be issued to camp personnel by Fubar's supply room.

(d) Do not arise before the blast wave arrives which takes about 50 seconds.

(e) At two (2) short blasts of the siren, indicating the passing of all hazard from light and blast, all personnel will "carry on" thereafter conforming with such directions as may be announced over the loudspeaker.

5. In event that evacuation becomes necessary, directions for this action will be broadcast on the loudspeaker and carried out in orderly fashion according to prepared plans.

6. Any possible hazard from ultra-violet light injuries to the skin is best overcome by wearing long trousers and shirts with long sleeves.

4.7 HEALTH AND MONITORING ORGANIZATION AND PREPARATIONS
(as of 20 June, 1945)

Louis H. Hempelmann, M. D.

4.7-1 Introduction

It is the purpose of the Medical Department to anticipate possible dangers to the health of scientific personnel, residents of nearby towns and of casuals; to provide means of detection of these dangers; and to notify proper authorities when such dangers exist.

It is also necessary to obtain records which may have medico-legal bearing for future reference.

The medical group will act in an advisory capacity and avoid direct orders to personnel except in cases of emergency. It is the responsibility of the Trinity Project Director to confirm or deny activities to scientific personnel which may be hazardous to them. It has been advised that no person should (of his own will) receive more than five (5) r. at one exposure.

Evacuation of towns or inhabited places will be carried out by G-2 personnel if necessary on advice from the Medical Department. Contaminated areas will be adequately marked and guarded until decontaminating procedures can be carried out.

4.7-2 Organization of Medical Group (TR-7)

A. Chief of Medical Group: ⟷ Consultants:

Hempelmann

Warren
Friedell

Deputy at TR: ⟷ Surgeon:

Nolan

Large
Humphries
Lerner

Instruments:

Watts
Scivally

Site Monitoring:

Aebersold
Barnett
Allen
Hageman

Outside Monitoring

Hoffman
Levine
Anderson
Green

Leonard
Brown

B. The Duties of Medical Group Personnel:

1) Hempelmann:

Generally in charge of operations. To have no regularly assigned duties, but to be ready at Base Camp for consultation.

2) Nolan:

To plan for medical personnel and equipment. To acquaint all personnel as to activities of Medical Group. To instruct medical personnel to their duties and responsibilities. To inform Trinity Director as to Medical Hazards.

3) Watts:

To construct and install all monitoring devices. To instruct monitors as to their equipment and duties.

4) Monitors:

To carry out readings and recordings as instructed.

5) Medical Officers:

To be available in case of catastrophe and to act as temporary monitors.

6) Consultants:

To be available at Base Camp for receipt of monitoring reports and to advise as to necessity of evacuation of contaminated areas.

C. Stations of Medical Group Personnel:

1) At Base Camp:

Hempelmann   Warren
Nolan   Large
Watts   Aebersold

2) At 10,000 Yard Shelters:

Barnett   Hageman
Allen

3) At Range Camp - Lava Bed:

Levine

4) At Highway 54:

Anderson

5) At Highway 285:

Green

6) At Highway 85

Leonard

Roving Monitor - Hoffman

7) In Airplane:

Members of Alvarez's Group

8) In Albuquerque:

Friedell

4.7-3 Equipment of Medical Group:

A. Transportation:

1) Ambulances:
   a. Panel type
   b. Field type

2) Four-Wheel Drive:
   a. Command car
   b. Carry-all

3) Sedan

4) On loan - Two four-wheel drive vehicles for taking scientific personnel into contaminated area. All available four-wheel drive vehicles for evacuating base camp.

B. Protective Clothing:

1) Coveralls - for people in shelters, Medical Group, Tank-group, and in-going personnel 100
2) Caps, surgical 100
3) Booties, various 100
4) Gloves, cotton 100

C. Gas Masks:

1) Positive pressure type - Tank Group . . 12
2) Smoke resistant type - in-going group . 30
3) Regular gas masks - Shelter group . . . 30
4) Respirators - all personnel at base . . 400

D. Instruments:

1) Portable gamma meters 15
2) Portable alphameters 20
3) Filter Queens 10
4) Recording gamma meters. . . . . 12 (Esterline-Angus)
5) Hand and Swipe Counter. 1
6) Regular pencils 200
7) Chargers 3
8) Resistant pencils 12
9) Film badges - catastrophe 100
10) Film badges - for towns 200

4.7-4 Plans for Monitoring - Before Shot:

A. Transportation of Material:

1) Courier to wear pencil and catastrophe badge
2) Container to be checked with small portable gamma and alpha meters.

B. Assembly

1) Dry box maneuvers to be checked with portable gamma meter.
2) Protective clothing and respirator worn before tamper is in place.
3) Check hand and nose counts of Pit Man

C. Raising of Material and H.E.:

1) Area to be cleared of unessential personnel before, during, and after this procedure.

4.7-5 Plans for Monitoring - Time of Shot:

A. At 10,000 yard Shelters:

1) All persons to remain inside shelters
2) One member of Medical Group at each shelter
3) Instruments and equipment

   a. portable gamma meter 1
   b. portable alpha meter 1
   c. pencil chambers or film badges for each person
   d. ordinary gas mask for each person

4) All personnel to leave for base camp within 30 minutes using gas masks.

5) a. Evacuate before 30 minutes if gamma reading outside shelter reaches 0.1 r/hr.
   b. Put on gas masks and evacuate if alpha reading reaches 5 c/m.

6) Adequate transportation to be checked by members of Medical Group.

B. At Base Camp:
1) All persons to be outside of buildings.
2) Observers of shot to wear protective goggles and avoid direct vision.
3) To stay at Base until contaminated area is ascertained -- 6 hours.
4) Member of Medical Group to be in communication with town monitors by phone and with plane monitors by radio.
5) Equipment and instruments:

   a. portable gamma meter
   b. portable alpha meter
   c. respirators
   d. adequate transportation for all personnel for evacuation
   e. tolerances - same as in V-A-5).

C. At Range Camp (Lava Bed):

1) Observe cloud and trail with radar and direct vision.
2) Instruments and equipment:

   a. portable gamma meter
   b. portable alpha meter
   c. respirators
   d. transportation

3) Tolerances - same as in V-A-3).
4) Communications -- radio to Base Camp

D. Member of Medical Group at Highway 54:

1) Check recording meters (alpha and gamma) at: Carrizozo, Oscura, Three Rivers, Tularosa.

2) Observe cloud visually and record course.

3) Observe readings of portable alpha meter beneath cloud.

4) Follow cloud towards east and continue with meter readings.

5) Communicate with Alburquerque by phone as to course, intensity of readings, etc.

E. Member of Medical Group at Highway 285:

1) Check recording meters (alpha and gamma) at Carlsbad and Roosevelt.
2) Observe cloud visually and record course.
3) Observe readings of portable alpha meter beneath cloud.
4) Follow cloud towards east and continue meter readings.
5) Communicate with Albuquerque by phone, as to course, intensity of readings, etc.

F. Member of Medical Group at Highway 85:

1) Check recording meters (alpha and gamma) at San Antonio.
2) Observe cloud visually and record course.
3) Observe readings of portable alpha meter beneath cloud.
4) Follow cloud towards east and continue meter readings.
5) Communicate with Albuquerque by phone, as to course, intensity of readings, etc.

G. Roving Town Monitor: (Hoffman)

1) Station himself at Carrizozo at time of shot.
2) Follow cloud visually and with portable meters.
3) Direct station and activities of ground monitors.
4) Confer with Albuquerque (W. Friedell) in case of need of evacuation at any point.

4.7-6 Plans for Monitoring - After Shot:

A. At Shelters 10,000 yards:

1) Evacuate area as soon as possible returning all personnel to Base Camp.
2) Check wearing of gas masks and pencil chambers.
3) Report on meter readings.

B. At Base Camp:

1) Receive reports from plane and surface monitors.
2) Send consultation group to dangerous areas if need be.
3) Check equipment, calculate dosage, instructions to personnel entering contaminated area to retrieve equipment. This is to be done by a Board consisting of Kenneth J. Bainbridge, Victor Weisskopf, and James F. Nolan with the aid of information obtained by Tank Team and from gamma sentinels of Moon. Men to wear coveralls, caps, boots, smoke masks, film badges, and direct reading electroscopes.

Nolan

4) Record gamma and alpha readings at Base Camp and evacuate if necessary. This must continue until all of Base Camp can be evacuated after 4 - 7 days.
5) Check equipment of Tank Team - before and after their activities.
6) Map out area of gamma contamination to tolerance limit (0.1 r/8 hrs.)
7) Map out area of alpha contamination to tolerance limit (five c/m on ground).
8) Set up wind-socks at various locations for ground wind direction.

C. At Highways and Lava Bed :

1) To report at Base after recording devices are secured and after cloud and trail have passed. Be prepared to proceed in direction of cloud if necessary. Return to base when advised to watch for and retrieve film badges dropped through cloud by plane.

D. Plane:

1) This to be performed by members of Alvarez's group and to be instrumented to carry out the following measurements:
   a. size of cloud
   b. shape of cloud
   c. course of cloud
   d. gamma intensity by direct reading at distance
   e. gamma intensity by dropping film through cloud at intervals.

E. Additional Measures:

1) Film to be sent to post offices of surrounding towns and be picked up by G-2 man and recorded.

4.7-7 Immediate Hazards:

A. Blast:

Hirschfelder's calculations 10 June, 1945 for an efficiency of 100,000 T. would yield at 10,000 M. - 0.69 p.s.i. and at 10,000 M. - 0.34 p.s.i. With such pressures, less than 1. p.s.i. bodily injuries will not occur. Ear injury may occur from 1 to 5 p.s.i.

B. Fragments

It has been calculated by Zimmerman (ref. memo to Bainbridge, 2 Oct. '44)

that the danger from fragments would be maximum in the case of a relatively small explosion of 60 to 500 tons. In this case, a fragment with a range of 10,000 yards would have to have an initial weight of from 230 to 500 pounds. A fragment of such a size would only result in the case of a non-symmetrical explosion using Jumbo. Even here, the maximum would probably be less than 10,000 yards.

C. Heat :

According to Hirschfelder the rise in temperature produced by the Blast Wave will probably be 40° instantaneously and within one second be only 1° at 10,000 yards.

D. Light :

With 10,000 T at 10,000 M -	1 sun for 1 millisec. 1/10 sun in 1 sec.
With 100,000 T at 10,000 M -	10 sun at 1 millisec. 1 sun at 1 sec.
With 100,000 T at 10 miles -	5 sun at 1 millisec. 0.5 sun at 1 sec.

Observers within 10 miles will not be injured and will be especially protected by smoked glasses.

E. Gamma Rays :

According to Weisskopf's maximum estimate of immediate gamma radiation, the amount delivered immediately would be 10^{-4} at 10,000 M.

F. Neutrons :

At 10,000 M the peak neutron flux would be less than one neutron per square centimeter, which is far below tolerance.

We find that all personnel housed in the shelters at the time of the shot will be adequately protected. However, premature detonation will be quite dangerous. For these reasons, persons working around the tower after the charge and pit are in place will wear "catastrophe badges" and precautions

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will be taken for the evacuation of injured persons and the treatment of blast injuries.

4.7-8 Delayed Hazards:

A. Ground Contamination:

Because of the necessity of retrieving scientific apparatus for records after the shot, the ground contamination becomes important. The alpha contaminated area will be appreciable, but will not be dangerous if the correct protective clothing is worn. The gamma contaminated area will be appreciable, but will shrink due to decay of the fission products. Although these areas must be measured at the time in questi   estimates of their size have been made in order to facilitate the placement and removal of apparatus. Calculations by Weisskopf and data reported by Anderson from the 100 T shot are used. They are enclosed in the appendix.

Due to the fact that the area of the crater will be contaminated with alpha particles and that these will be closely associated with fine particles of dust on the surface of the ground, it will be necessary to bind the dirt in this area rather closely and bury it later. Local winds are variable and danger from breathing contaminated air will be ever present unless this is done. This area of alpha contamination will represent an "attractive hazard" to the curious even though it be fenced off and adequately marked.

The area of alpha contamination will be monitored by Anderson's dirt samples from the tank; also, the area of contamination will be marked by the Medical Group in the following manner: A portable alpha meter designed by Watts which can read accurately 5 c/m will be wheeled into the area. Dirt scooped up in a measured plate which gives this reading will indicate that if all the dirt in this area were dispersed in the air, one would inhale the tolerance dose of 49 in 14 minutes... People entering this area will wear protective clothing and smoke masks.

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Calculations:

1 ugm = tolerance dose = 140,000 dis/min.

= 70,000 counts/ min.

Respiration = 15,000 cc/min (100 per cent retention assumed)

Meter has window - 2 cm x 9 cm with 8 mm thin wall window.

Alpha range in air = 4 cm. in air or 3 cm. in front of window.

Vol. measured by meter = 2 x 9 x 3 = 53 cc = 1/20 liter.

Effective geometry = 30 per cent

Best practical reading = 5 c/m

In air - 5 c/m in 60 cc.

= 1500 c/m in 15,000 cc

$= \frac{1500 \times 3}{70{,}000} =$ 1/16 tol. dose per minute

or tolerance dose 1 ugm in 16 min.

Gamma contaminated area will be measured by Anderson and Moon's sentinels. These figures will be used by Weisskopf to calculate time and duration of entrance of personnel. Also, the Medical Group will outline the region of the tolerance level 0.1 r/8 hr. with portable gamma meters.

B. Cloud Contamination:

The activity of the cloud will vary with the efficiency of the explosion and measures to monitor it until it is dispersed must be taken since it represents a possible dangerous hazard to the population of the surrounding territory. Also definitive measurements must be obtained for medico-legal reasons. However, the size, shape, and activity of the cloud have been calculated in anticipation and are enclosed in the appendix. Also, its course of probable action are discussed in section IX under Meteorology. A description of the monitoring by airplane will be furnished by Alvarez and Waldman, who are undertaking the procedure.

C. Trail Contamination:

There is a probability that loose dust from the crater and surrounding area which will be drawn upward by the hot air currents, may form nuclei upon which radio-active materials will condense. It has been calculated by Hirschfelder from actual measurement of the TR dust and the surface area afforded by the particles that if this dust should rise to 10,000 feet and then fall at a normal rate there may be danger to towns 30 miles away. His calculations are based on pessimistic assumptions, but the possiblity of this happening cannot be excluded. The calculated amount of radiation resulting is 7 r/hr for fission products and 1 ugm of 49 in 22 hours at normal respiratory rates.

It is most probable that there will be a seleptivity of particles by the updraft, so that only dust of small diameters will reach this height, that is, 100 micron or less. Also, it is probable that the cloud will ascend higher than 10,000 feet resulting in greater dispersion and dilution if these particles should fall. It is also probable that these particles will not fall at a normal rate, but will be held together by electric forces. Also, the probability that the cloud will pass over populated places is not certain.

In any case, this possibility will be watched for by the town monitors and steps taken to evacuate the town if danger is emminent. As the decay rate procedes as 1/t, there should be adequate time to cause evacuation after contamination is noted. The ultimate decision will be made by the Medical Consultants with the complete information at hand after the shot.

4.7-9 Meteorology:

The TR number 2 shot will occur during a time when meteorological conditions are similar to the 7 May shot. As far as the medical considerations go, the main planning for monitoring the surrounding territory has been with this in mind. Mr. J. Hubbard has reasonably assured all concerned that these conditions

are predictable at least 6 days in advance.

A summary of the conditions to be expected and their bearing on the cloud is as follows:

1) The humidity will be low enough to exclude the causation of a thunder shower by the blast and heat effects of the explosion. Such a thunderstorm would be dangerous in that it might cause the precipitation of the active material over a small area which could not be controlled.

2) There will be a small temperature inversion over the site and surrounding territory from 1000 to 1700 feet high. This will retard heavy particles in traveling any great distance and impede lighter particles which have penetrated the inversion from falling back through it. The latter effect will tend to protect the nearby towns until the morning thermals have mixed the active material more thoroughly.

3) Above the inversion there will be at least a 30 mile per hour wind towards the South East. This will carry the cloud beyond the nearby towns giving the active material time to diffuse somewhat and become more dilute.

4) Five miles from the site there is a range of mountains 4,000 feet above terrain. With the winds in the South East direction this range will cause an increase in the velocity of the winds above it to 10,000 feet. This will give a "shearing effect" to the trail at the bottom of the cloud. What material from the trail that is not deposited on the West face of these mountains will be diffused by the high turbulance of the winds. Some 50 miles from the site there is another range of equal height which by the same effect will spread and diffuse material which may have started to fall from the cloud.

5) There will be a slightly stable atmospheric lapse rate. The effect of this will be to allow the ball of fire to ascend until stopped by a higher inversion. This higher inversion is expected to be from 20,000 to 25,000 feet. In the 100 T shot, the height reached was from 12,000 to 14,000 feet because of a slight inversion at that height. The energy of the TR number 2 shot will probably

be enough to exceed such a slight inversion as this one was, but all calculations as to the action of the cloud have been on the basis of 12,000 feet. The higher the cloud ascends, the less danger from heavy active particles falling on a small area. We are assured that the lapse rate will exclude any possibliity of the cloud descending.

6) The usual heating of the earth at about 9:00 A.M. will start the general movement of air in an ascending manner as the inversion is broken. Besides this there will be rather large updrafts or thermals. The effect of this will be to disperse the cloud in the matter of a few hours. The cloud's station at this time will be about 250 miles from the site and again we have been reassured that no local thunderstorms will form which could "suck in" the entire cloud and deposit it over a small area.

7) Mr. Hubbard finds it conceivable that contaminating material thrown in the air will remain at high altitudes until thoroughly mixed and may be suspended for a matter of weeks (for example the volcanic dust and surface dusts from the interior of China).

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For additional medical preparation and for last minute changes in Health Program, see "Preparation and Operational Plan of Medical Group (TR-7) for Nuclear Explosion 16 July, 1945", compiled by Louis Hempelmann, M.D. .

CHAPTER 5

WORK PRECEDING AND INCLUDING ASSEMBLY AT TRINITY

by Capt. W. F. Schaffer

5.1 PRELIMINARY TESTS

The assembly of the H.E. charge in its case for the Trinity bomb was preceded by certain tests at Site Y. These tests were made to study method of loading and effects of transportation. In the first part of the test an inert unit was used and the method evolved for loading the unit in the truck was to set the unit on an assembly tub which had been bolted to the truck bed, with the polar cap up. Then the sphere was fastened in place by 1/4" steel cables running from each ellipsoid attachment lug to eyebolts on the truck bed. This method worked satisfactorily and on 3 July the unit was driven to Trinity without any difficulty. The speed of the truck was maintained not to exceed 30 miles an hour on smooth highways and slower speed as the condition of the road indicated. Periodic half-hour inspections of the lashings were made.

The complete procedure which was anticipated for the hot run was followed through in a dry run (see appendix Ser. No. 19). The procedure for the final assembly of the bomb at the base of the tower was carefully planned in advance by all parties concerned. The procedure decided upon was followed step by step and note was made of desirable changes for the hot run. The dry run was completed and the unit was returned to Site Y by 6 July.

On 7 July a mock-up H.E. charge with four actual lens charges was delivered from S Site for assembly. The charges were prepared

and the assembly was made on 8 July. (The assembly procedure is not given here since it is stated in detail in another volume of the Los Alamos Technical Series.) On 9 July this unit was driven for eight hours over a rough course to determine what effect transportation to Trinity might have on the actual lens charge. It should be stated at this point that up to now there had been insufficient full scale lens castings made to make a complete charge. After three hours driving time, the top polar cap was removed for inspection and the charge was found to be in excellent condition. The next day the unit was completely disassembled and each casting was inspected to determine its condition. Inspection proved satisfactory and revealed that all charges had withstood the test and were in perfect condition.

5.2 PREPARATIONS AT Y

On the evening of 10 July castings for two assemblies were received. These castings were to make up the Trinity charge and the Creutz charge. G. B. Kistiakowsky and N. E. Bradbury, together with all S Site personnel concerned with the inspection of charges, held a conference in which all records were reviewed and disposition of the castings was made according to their quality. The following day the castings were personally inspected by Kistiakowsky and Bradbury for chipped corners, cracks, and other imperfections which were undesirable. Only first-quality castings which were not chipped or which could be easily repaired were used for the Trinity assembly. The remainder of the castings were diverted to the Creutz charge.

By mid-afternoon of the 12th, the Trinity charge was complete. With the interested personnel present an inspection of the charge was made by removing each polar cap. Because of the specially prepared case, further inspection of the charge was possible. This case had been drilled with 1" holes located at the corner intersection of each casting. The charge was found to be as satisfactory as possible according to our best knowledge at the time. The case was then closed up, all booster holes were sealed and the unit was wrapped in a Butvar (waterproof wrapping material) bag,

sealed and lashed firmly to the truck in preparation for the haul to Trinity. The castings which were to be used in place of the dummy trap door plug were boxed together with one spare casting of each type. At midnight of 12 July, the preassembled bomb started on its way to Trinity. G-2 escort cars preceded and followed the bomb. Prior to noon on 13 July the charge arrived at the base of the tower and assembly operations began at 1300.

5.3 PROCEDURE FOR FINAL ASSEMBLY

The procedure used for the final assembly of the bomb is probably best given by the memorandum from N. E. Bradbury which gives the procedure to be followed as discussed by all members concerned and which was evolved from the dry run.

TR HOT RUN

by N. E. Bradbury

1. The firm dates for the TR Hot Run are as follows:

Saturday, 7 July, 1700	Schaffer Shake Test ready to deliver
Sunday, 8 July, 0830	Assemble Schaffer Shake Test, load on truck
Monday, 9 July, 0830	Schaffer Shake Test charge given eight-hour road test. Remove polar cap and dummy plug and inspect top of charge only after three hours riding.
Tuesday, 10 July, 0830	Completely disassemble charge and inspect each casting for condition. Verbal report of charge condition by 1630 Tuesday PM. Reassemble and remove.

Wednesday, 11 July, 0830	Information will be furnished as to which charges will be used in TR shot and which in Creutz shot. Separate charges. Complete papering of TR charges. Complete papering of Creutz charges (use separate groups—request additional personnel as needed.)
Wednesday, 11 July, 1730	Both charges completely papered. Work another night shift if necessary to complete this job. Request personnel as necessary. This job must be done so that assembly of both charges can start on Thursday, 12 July, at 0830.
Thursday, 12 July, 0830	Use two groups—one at V Site to assemble TR charge (Lt. Schaffer supervise), and one at Pajarito for Creutz charge (Mr. North supervise). Tamper needed by 1000 at V Site.
Thursday, 12 July, 1500	Assembly of TR charge complete. Notify interested personnel that it is ready for inspection if desired.
1600	Seal up all holes in case; wrap with Scotch wrap (time not available for strippable plastic), start loading on truck. Tie down to truck body.
1600	Box charges, inner and outer, with 2 spares for each. Stow on truck so they cannot shift, and are padded from truck bottom.
Friday, 13 July, 0001	TR charge starts on its way to TR. G-2 escort cars fore and aft. G.B.Kistiakowsky to ride in fore car.

Friday, 13 July, 1200 — TR charge arrives at base of tower. Following personnel to be at base of tower by 1300:

N. E. Bradbury
G. B. Kistiakowsky
R. S. Warner
H. Linschitz
Lt. W. F. Schaffer
T/3 Jercinovic
T/3 Van Vessem
A. B. Machen

Friday, 13 July, 1300 — Assembly starts at this time.

A. Unloading at TR

1. Truck backs up into base of tower.

2. Tarpaulin is removed, cradle and assembly unlashed.

3. Main hoist lifts sphere off cradle with spreader bar or tongs.

4. Drive truck out from under sphere.

5. Place new cradle under hoist and lower sphere suspended by tongs into it with main hoist.

B. Assembly at TR

1. Sphere is now resting on cradle with polar cap up.

2. Detach main hoist; pick up gently with hook, lower, pull out over gadget and secure.

3. With jib hoist, remove polar cap and dummy plug. Special polar cap and funnel put in place. Gadget now belongs to tamper people (at about 1400 on Friday). Prior to their taking over, a fifteen-minute period will be available for generally interested personnel to inspect the situation. After this time, only G engineers and two representatives from the assembly team will be present in the tent.

4. G Engineers work till 1600 with active material insertion.

5. Light must be available to work in tent at night.

6. At 1600, dummy plug hole is covered with a clean cloth, and He-Me people take over. Attach tongs to tent peak by chain. Place tongs on trunnion. Lift sphere and turn over with jib hoist for HE insertion. Return sphere to cradle.

7. Place in hypodermic needle <u>in right place</u>. (Note: Check this carefully.)

8. At this point another 15-minute period will be available for inspection by generally interested personnel.

9. Insert HE - this to be done as slowly as the G Engineers wish. Have on hand extra paper if charges are slightly small. Also grease and hypodermic needle grease gun. Be sure glass tape and/or shim stock shoe horn is on hand.

10. When HE has been inserted and He-Me people and G Engineers are satisfied that all is OK, another inspection period of 15 minutes will be available.

11. Lift sphere with tongs by chain to tent peak. Return to polar cap up position. Remove special polar cap with jib hoist; replace with regular polar cap.

12. Turn sphere over with tongs, chain and tent peak so that lug is up.

13. Place sphere in special cradle for tower top, and attach cradle firmly to sphere. Remove all tongs, chains, etc., and generally clear deck.

14. Leave tent in place till morning.

*NOTE: The HE vacuum cup has arrived and appears to be extremely useful in handling HE charges. It is possible that the entire assembly may be done in the vertical position using the jib hoist and vacuum cup to lower the HE as slowly as the G Engineers wish. This would then require no handling between tent peak and tongs, and the sphere will be left overnight with the <u>cap up</u> and in small dishpan.

*Vacuum cup actually used for handling charges.

15. It is anticipated that we will leave the tent (guarded) at about 2200.

Saturday, 14 July, 0800 Lift to tower top

1. Remove tent with main hoist.

2. Turn over with main hoist and place on special cradle. (This operation necessary only if not previously done as it would not be in a vertical assembly.)

3. Rig guide lines.

4. Lift to tower top. Ready for X unit at 0900.

5. Bring up G Engineer footstool.

Saturday, 14 July, 0900 Operations Aloft

1. Wiring of X unit proceeds direction of and by He-Me people. Note that X unit should have cables attached to cone prior to this time.

2. Detonators are staked to coax by Caleca of detonator group.

3. Detonators are placed by Caleca to conform with requirements of informer switches. HE people stand by to criticize potential rough handling.

4. Detonators and informers in place, verified by Greisen.

5. X unit and informer unit safed, verified by Bradbury or Kistiakowsky.

6. X-7 will provide all detonators, informer switches, informer cables (adequate length), informer apparatus (where they get it is their business). X-5 will supply prepared detonator cables. X-6 will obtain detonator springs and other necessary gear from appropriate sources. X-6 will supply all fittings for wiring. Schaffer to check that all mechanical parts (nuts, bolts), etc. are supplied.

7. Note that once detonators are on sphere, no live electrical connection can be brought to X unit, informer unit, or anywhere else on sphere. Hence all testing must be done before sphere is lifted to tower. After that it is too late.

Saturday, 14 July, 1700 Gadget complete

Sunday, 15 July, all day	Look for rabbit's feet and four leafed clovers. Should we have the Chaplain down there? Period for inspection available from 0900-1000
Monday, 16 July, 0400	Bang!

General Notes

The same responsibility for procurement of items exists as in the dry run. Machen to check his list for parts left down there. Could they have been stolen? Schaffer to get vacuum cup and two pumps ready to go down. Have glass tape handy to tie charge to hook of jib hoist to guard against vacuum failure.

It is assumed that the following things will have been done at TR:

Guide wire hold down improved

Method of holding down tent improved

Ionization chambers either not connected to pipe coax or off to one side. Wilson's chamber to be connected later; Rossi's chamber to be pulled off to wall side.

Rig a roped off area about base of tower allowing 20 ft. clear space. Provide "Keep Out" signs (Oppenheimer). All spectator personnel stay outside this area except at inspection times.

The following points were noted in the dry run assembly. Personnel listed should take appropriate steps:

Shim stock shoe horn was missing. (Machen)

Longer screws needed for X-unit cable clamps. (Schaffer)

Sphere not grounded. (Schaffer)

All detonators off floor; all detonator cables off floor. (Greisen)

Shorter screws could be used for detonator leaf springs. (Schaffer)

Washers needed for informers. (Greisen)

Cable lengths too short? (Hornig)

Headless screws to protect screw holes (not necessary with Scotch wrap).

Need good cover for HE hole while turning over. (Schaffer)

Need proper clevis for attaching tongs to main hoist. (Henderson)

Need better method of getting up tent and securing. (Henderson)

Upper platform should be tested with concrete weight. (Oppenheimer)

It will not be possible to permit any personnel on the assembly platforms other than those actually engaged in assembly operations. However, personnel may observe the operations from beyond the roped off area, and may inspect the assembly at times as noted in the above operations list.

(Signed) N. E. Bradbury

Distribution:
J. R. Oppenheimer
F. Oppenheimer
G. B. Kistiakowsky
Major Ackerman
R. W. Henderson
R. S. Warner
Lt. Schaffer (2)
A. B. Machen
Morrison
Holloway
R. F. Bacher
N. Ramsey
K. T. Bainbridge
Lt. Comdr. Keiller
K. Greisen
D. Hornig
H. Linschitz
R. W. Carlson
John Williams
B. Rossi
R. Wilson

CHAPTER 6 [redacted] UNCLASSIFIED

RADIAL DISTRIBUTION OF NEUTRONS, GAMMA RADIATION AND THERMAL RADIATION

John L. Magee

6.1 INTRODUCTION

In this chapter we shall present the Trinity experimental data on the radial and time dependence of radiation intensities. These data are not very extensive, and we shall supplement them in places with results obtained in the air burst test at Bikini (Test "Able"). Radiochemical evidence shows that these two bombs were identical in efficiency, so a direct comparison is indicated. The experimental results will be accompanied by a limited amount of comparison with theoretical expectation and interpretation.

Theoretical predictions were made for neutrons and gamma radiation by Weisskopf[1,2] before the Trinity shot. These predictions were very useful

(1) V. Weisskopf, LAMS 218.

(2) V. Weisskopf, LAMS 250 and LAMS 250A

in planning experimental measurements, and the agreement obtained was quite good. The only pre-Trinity discussion of thermal radiation was made by Magee and Hirschfelder.[3] A more complete discussion of radiation phenomena

(3) Group T-7 report in "Theoretical Division Progress Report for February, 1945" LAMS 221

connected with air blasts appears in this Technical Series.[4]

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References

1.	V. F. Weisskopf	LAMS 218	Neutron and Gamma Ray Effects after the Nuclear Explosion. I
	V. F. Weisskopf	LAMS 250	Neutron and Gamma Ray Effects after the Nuclear Explosion, II
2.	H. L. Anderson N. Sugarman	LA 356	Determination of Nuclear Efficiency.
3.	O. Chamberlain, et al	LA 432	Delayed Gamma Ray Measurements at Trinity
4.	P. B. Moon P. Abersold, P. Moon	LA 433 LA 359	Measurement of Delayed Ionization by Distant Recording Instruments. Radiation Survey of Trinity Site Four Weeks after the Explosion.
5.	I. Halpern P. B. Moon	LA 430	Attempt to Obtain Gamma Ray Kinephotographs.
6.	D. Williams P. Yuster	LA 353	Total Radiation
7.	J. Blair, et al	LA 367	Neutron Measurements with Cellophane Catcher Camera.
8.	E. Klema	LA 362	Neutron Measurements with Gold Foil Detectors.
9.	E. Klema	LA 361	Fast Neutron Measurements Using Sulphur as the Detector.
10.	R. Sutton	LA 363	Measurement of Implosion Time.
11.	R. Wilson	LAMS 232	Methods of Measuring Initial Multiplication Rate.
12.	H. Bridge J. DeWire T. Snyder	LA 540	Measurement of Neutron Multiplication Rate.
13.	B. Rossi	LA 434	Measurement of Multiplication Rate.

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CHAPTER 8

SUMMARY OF MECHANICAL EFFECTS

100 Ton Test and July 16th Nuclear Explosion

by J. H. Manley

Sec. 8.1 INTRODUCTION

In order to have a summary of mechanical effects for easy reference, the data from various reports on both the 100 Ton Test and the July 16th Nuclear Explosion have been collected in Sec. 8.2. These data are also shown graphically in Fig. 8.

The data have been selected in the sense that uncertain values have been omitted, and in some cases of apparently equal weight an average has been used in tabulation. Occasionally more than one value by a single method appear at a given radius. These derive from equipment at different directions from the explosion. The difference in results for these cases is not great enough to suggest a significant asymmetry in the explosion. For complete details and description of the instrumentation, the original reports as indicated in Sec. 8.2 should be consulted.

The most extensive data on both explosions was obtained from the excess velocity measurement and from foil gauges. Neither method gives as precise information as desired; the velocity method involves an average between two distances, the foil method involves discrete pressure increments. However, by scaling the results of the 100 Ton Test (103 tons TNT equivalent neglecting any effects of wood boxes) one has:

Figure 8

Data for 100 Ton Test and for the July 16th, 1945 Nuclear Explosion.

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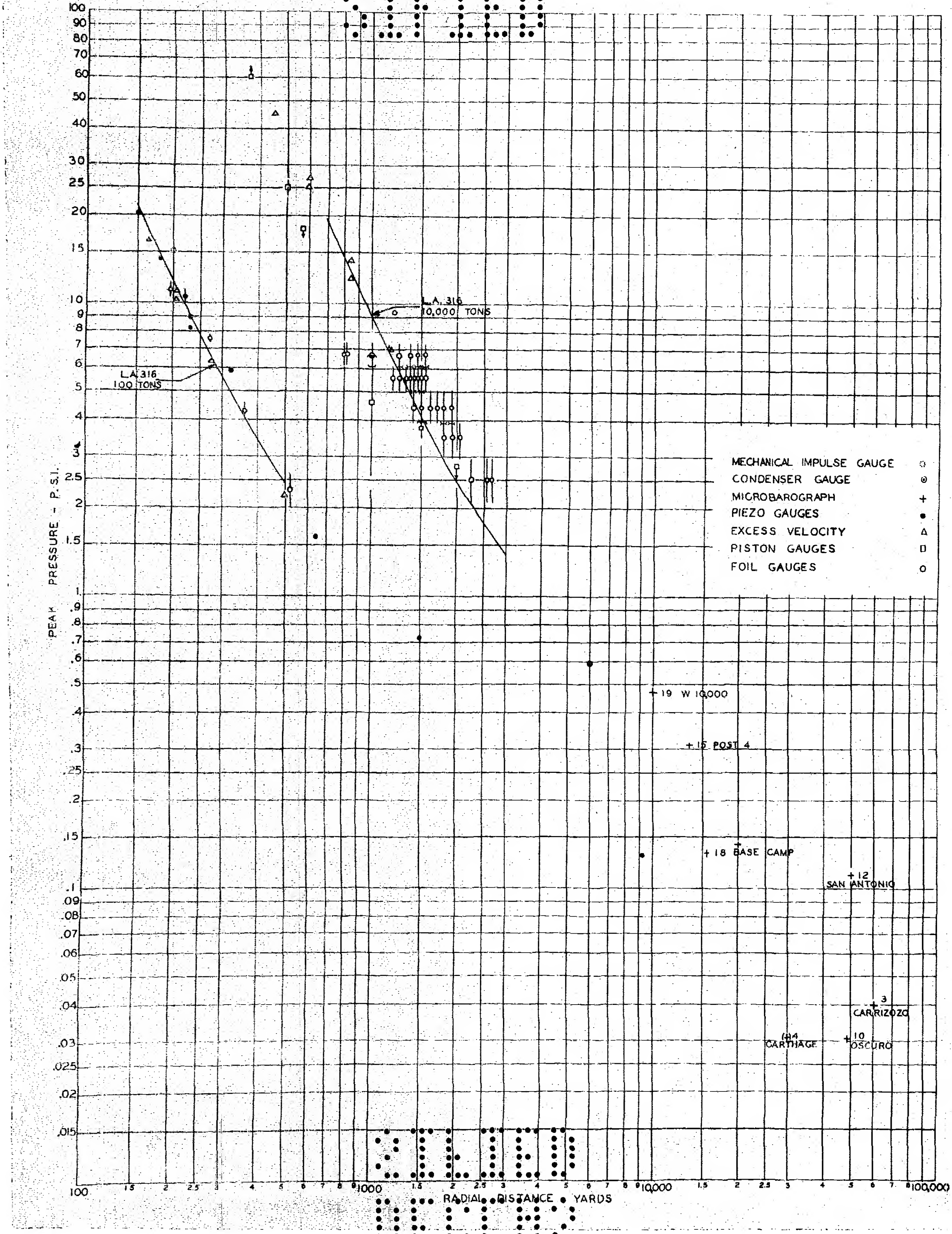

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Method	Nuclear Explosion, TNT equivalent in tons
Foil Gauges	9900 ± 1000
Excess Velocity	10,000 ± 1000

Measurements of earth motion show that earth shock is unimportant as a damage producing agent in comparison to air blast. Different methods of scaling test results give values from 3000 to 15,000 tons TNT equivalent for the nuclear explosion.

Sec. 8.2-1 AIR BLAST

July 16th Nuclear Explosion — 100 Ton Test

MECHANICAL IMPULSE GAUGE

LA-355		LA-284
Radial Position:	1200 y	200 y
Peak Pressure	9.4 ± 15% psi	15 psi
Impulse	1.77 ± 6% psi-sec	0.426 psi
Duration	0.65 ± 5% sec	0.130 sec

CONDENSER GAUGE

LA-366		No record
Radial Position:	6000	
Peak Pressure	0.58 ± 0.03 psi	
Impulse	0.45	

MICROBAROGRAPHS

LA-360 — Not used

Radial Position x 10^{-3} yds	Peak Pressure psi
10.0	0.47
13.4	0.31
15.5	0.13
48.3	0.03
50.0	0.11
60.5	0.04
63.3	0.03
78	0.008

July 16th Nuclear Explosion — 100 Ton Test

PIEZO GAUGES

July 16th Nuclear Explosion: No record

100 Ton Test: LA-286

Radial Position yds	Peak Pressure psi	Impulse psi-sec
150	20.4	--
180	14.2	--
230	8.2	.470
230	9.0	.556
320	5.9	.346
740	1.6	.172
1500	0.73	.073
9200	0.13	.015

EXCESS VELOCITY

July 16th Nuclear Explosion: LA-352

Radial Position yds	Peak Pressure psi
448.7	45.2
593.2	25.3
593.3	27.2
838.4	14.0
838.4	12.2
1185.1	7.0
1184.9	7.1

100 Ton Test: LA-291 - records ambiguous

LA-286

Radial Position yds	Peak Pressure psi
164	16.2
204	10.2
204	11.0
272	6.3
498	2.2

PISTON GAUGES

July 16th Nuclear Explosion: LA-350

Radial Position yds	Peak Pressure psi
367	> 60
500	24 - 26
567	< 18
1000	2.6 - 6.7
1500	3.5 - 4.0
2000	> 2.8

100 Ton Test: Not used

July 16th Nuclear Explosion

100 Ton Test

FOIL GAUGES

LA-354

Radial Position yds	Peak Pressure psi
800	6.18 - 7.35
814	6.18 - 7.35
1000	6.18 - 7.35
1190	5.09 - 6.18
1250	6.18 - 7.35
1250	5.09 - 6.18
1320	5.09 - 6.18
1360	6.18 - 7.35
1360	5.09 - 6.18
1400	3.96 - 5.09
1400	5.09 - 6.18
1445	5.09 - 6.18
1445	6.18 - 7.35
1490	3.96 - 5.09
1490	5.09 - 6.18
1550	5.09 - 6.18
1550	6.18 - 7.35
1620	3.96 - 5.09
1710	3.96 - 5.09
1800	2.97 - 3.96
1800	3.96 - 5.09
1920	2.97 - 3.96
1920	3.96 - 5.09
2050	2.97 - 3.96
2250	2.10 - 2.97
2550	2.10 - 2.97
2675	2.10 - 2.97

LA-288
Data revised in LA-354

Radial Position yds	Peak Pressure* psi
195	10.5 - 11.8
220	10.0 - 11.2
270	7.4 - 7.7
360	4.0 - 4.6
520	2.0 - 2.6

*Range given in lowest value of Table V column 6 to highest value Table V column 7, p.10 of LA-354

CRUSHER GAUGES

LA-431

Radial Position feet	Max. Pressure tons/sq.in.
327	1.10
328-1/4	1.34
320-1/4	1.26
322	1.36
208	4.95

Not used

Sec. 8.2-2 EARTH MOVEMENT

July 16th Nuclear Explosion			100 Ton Test		

GEOPHONES

LA-351

LA-351			LA-287		
Radial Position yds	Max. Displacement cm		Radial Position yds	Max. Displacement cm	
	Hor.	Vert.		Hor.	Vert.
800	--	1.2	800	.030	.033
1500	.75 (.52)	-- (.36)	1500	.010	.018
9000	.019	.02	9000	.0018 (.0033)	-- (.0028)

Values in parenthesis were obtained at approximately 150° from other values listed. These are derived results (from velocity and periods) and are accurate to about 50%.

SEISMOGRAPHS

LA-438		LA-439
Radial Position yds	Max. Displacement cm	Not used
	Horizontal-Radial	
9000	0.068	

PERMANENT DISPLACEMENT

See LA-365 See LA-283

CHAPTER 9

JULY 16TH NUCLEAR EXPLOSION - SUMMARY OF OPTICAL OBSERVATIONS

Julian Mack

9.1 INTRODUCTION

The observations of the Optics group fall roughly into two catagories: space-time relationships (LA-531; most of the space-time material presented here is taken verbatim from the abstract in that report) and the analysis of the emitted light (LA-353; LA-588). A semi-popular account of the explosion, in titled pictures, has been issued as LAMS-373.

9.2 SPACE-TIME RELATIONSHIPS

For the determination of space-time relationships approximately 10^5 photographic exposures were made, almost all of them motion picture frames. Most of the resultant data are shown in Figure 9 (from LA-531). A summary of the events observed follows: the expansion of the ball of fire before striking the ground was almost symmetric, following the relationship

$$R = 616\ t^{2/5}$$

(where R is the radius in meters, and t is the time in seconds), except for the extra brightness and retardation of a part of the sphere near the bottom, a number of blisters, and several spikes that shot radially ahead of the ball below the equator. Contact with the ground was made at 0.65 ± 0.05 milliseconds. Thereafter the ball became rapidly smoother. From 1.5 to 32 milliseconds the time dependence of the shock radius followed closely the relationship

$$R = 564\ (t + 4 \cdot 10^{-4})^{2/5}$$

At 3 milliseconds there appeared at the bottom of the ball an irregular line of demarcation, below which the surface was appreciably brighter than above;

this line rose like the top of a curtain until it disappeared at the top of the ball at about 11 milliseconds. Shortly after the spikes struck the ground (about 2 milliseconds) there appeared on the ground ahead of the shock wave a wide skirt of lumpy matter, and within and above the skirt a smooth belt (interpreted as the Mach wave), originally brighter than the main wave but rapidly growing dimmer. Two successive visible fronts dropped behind the well-defined shock wave. The brighter but less sharply limited ball of fire fell behind it at about 16 milliseconds (105 meters). At about 32 milliseconds (144 meters) there appeared immediately behind the shock wave a dark front of absorbing matter, which traveled slowly out until it became invisible at 0.85 seconds (375 meters). The shock wave itself became invisible at about 0.10 seconds ($2.4 \cdot 10^2$ meters) but was followed thereafter to 0.39 seconds (460 meters), first by its light-refracting property and later by the momentum it imparted to a balloon cable.

The ball of fire grew ever more slowly to a radius of about $3 \cdot 10^2$ meters, until the dust cloud growing out of the skirt almost enveloped it. The top of the ball started to rise again at 2 seconds. At 3.5 seconds a minimum horizontal diameter, or neck, appeared one-third of the way of the skirt, and the portion of the skirt above the neck formed a vortex ring. The neck narrowed, and the ring and the fast-growing pile of matter above it rose as a new cloud of smoke, carrying a convection stem of dust up behind it. A boundary within the cloud, between the ring and the upper part, persisted for at least 32 seconds. The stem appeared twisted like a left-handed screw. The cloud of smoke, surrounded by a faint purple haze, rose with its top traveling at 57 meters per second, at least until the top reached 1.5 kilometers. The later history of the cloud was not quantitatively recorded.

Data not shown in Figure 1 include quantitative measurements on the refraction of light, and the material velocity behind the shock front, in certain intervals; the former can be made to yield the material density as a function of radius, behind the shock front (LA-531).

9.3 ANALYSIS OF THE EMITTED LIGHT

For the analysis of the emitted light, we have density readings on motion-picture negatives; quartz-prism spectrograms for the first few milliseconds with time resolution of the order of 10^{-5} seconds, and for the first one-fifth of a second with lower resolotion; photocell records (partly usable) of the light intensity for the first second, and thermopile records showing that the total radiant energy density received at 10^4 yards was $1.2 \cdot 10^7$ ergs cm^{-2} $\pm \sim$ 16 per cent.

The following observations, among others, appear to deserve special notice.

During the earliest stages observed by us (radius $\propto$ 10 to 10^2 meters) the shock wave radius followed Taylor's two-fifths power law: radius time 2/5.

The shock wave was markedly deformed by the platform; more-over, the radius in other directions was influenced by the presence of the platform.(1)

(1) cf. Bethe and Fuchs, "Los Alamos Technical Series, Volume 7".

A skirt of hot, lumpy matter, thus far unexplained, rose from the ground ahead of the Mach wave.

The Mach wave was clearly discernible throughout the interval $\sim 10^{-2}$ to 10^{-1} seconds, and information is available on its kinematics and on its brightness, opacity, and material density.

The dropping of the ball of fire behind the shock wave produced a minimum in the brightness curve, as predicted.(2)

(2) Hirschfolder and Magee, LAMS-221, the theory is discussed in "Los Alamos Technical Series", Volume 7, Chapter 4.

The shock wave was followed, at an increasing time interval as its pressure and temperature decreased, by a sharply defined dark wave front of absorbing material, evidently consisting of one or more of the colored oxides of nitrogen; the dark wave broke away from coincidence with the shock wave at about 144 meters, and grew asymptotically to a radius of about 360 meters before it became indiscernible.

The velocity of the shock wave unexpectedly remained nearly constant at twice sound velocity during the expansion in radius from ~ $2.5 \cdot 10^2$ to $4 \cdot 10^2$ meters, decreasing by only 15 per cent in this interval instead of dropping nearly to the ordinary velocity of sound. While a slight increase in sound velocity might have been expected from the sudden heating of the air around the ball of fire by radiation, the predominant cause of the observed maintenance of velocity appears to be the radiant heating of the shock front by energy absorbed by the dark front as ultraviolet or visible radiation and transformed there to lower frequencies, as suggested by Magee.

The emission spectrum had a violet cutoff that was a function of the time; the highest wave number emitted at any time was $3.34 \cdot 10^4$ cm^{-1}, which coincides within the error of the determination, with the cutoff characteristic of ozone formation.

CHAPTER 11

RECOMMENDATIONS FOR FUTURE OPERATIONS

11.1 MEASUREMENTS

These recommendations are made on the basis that the gadget under test incorporates some radical changes in design from the Model 2 used at Trinity and at Nagasaki. Therefore the most important measurements of the test will be those concerned with the internal behavior of the gadget and the measurement of its energy release. Two cases should be considered...a ground test and an air drop test over ground.

A ground test has the advantage of giving the maximum amount of information concerning the behavior of the gadget and it would permit fundamental physics experiments to be carried out which could only be conducted at great cost in time and personnel or could not be conducted at all if an air drop test were made.

There have been newspaper accounts that the Navy has definitely decided on the tests of one or more gadgets from the stock pile. If this program goes through, then in addition to the measurements recommended for an air drop test it would be useful to plaster the Navy ships inside and out with gold foil, sulfur and U-235 neutron detecting equipment and equivalent films and automatic recording ionization chambers for gamma rays. These should be buoyant and recoverable in the event the ships so treated are sunk during the test.

11.1-1 Ground Test

The recommendations for experiments which should be included

in the ground test are as follows (for details refer to the chart on experiments for the July 16 nuclear explosion, Chapter 10):

	Changes or Remarks
I. IMPLOSION	
1. Detonator Asimultaneity	-
2. Shock wave transmission time	-
3. Multiplication factors (b, c)	Three sets of equipment for maximum accuracy at different generation times.
II. ENERGY RELEASE by Nuclear Measurements	
Prompt γ and delays. Total γ irradiation	More for medical reasons. Not used in Trinity test.
2. Delayed neutrons (a, b, c)	-
3. Conversion of Pu to fission products	-
(a) On ground	-
(b) In air	Extension over TR program
III. DAMAGE, BLAST AND SHOCK	
BLAST	
1. Piezo gauges	Thermally insulated by concentric aluminum foil shells
2. Condenser gauges (a) On ground (b) Dropped from airplanes	The number cannot be increased over that planned for the TR test because of crowding of radio channels. If it is desired to increase the number of gauges, then considerable development will have to be done.
3. Excess velocity (a)	This was one of the most successful blast measuring methods

	Changes or Remarks
BLAST (cont.)	
4. Peak pressure (a,b,c)	Many more of these gauges should be used if they can be developed into reliable instruments
(d)	Inexpensive and reliable
5. Remote pressure barograph recorders	These are necessary for legal reasons
6. Shock wave expansion	From ground sites, and from airplanes for practice for future tests
EARTH SHOCK	
2. Seismographs - Leet	These are necessary for legal reasons
3. Permanent earth displacement	This is a simple measurement and is of interest because of the new phenomena encountered in the July 16 test
4. Remote seismographs	The reverend seismographers will never forgive you if you don't give them a warning of the test.
IGNITION OF STRUCTURAL MATERIALS	The Army, the Navy and de Seversky will want to define this.
IV. GENERAL PHENOMENA	
1. Behavior of Ball of Fire (a,b,c,d,e) 2. Rise of Column (a) 3. Mushrooming and Lateral Movement (a,b,c,d) Radiation Characteristics 2. Total Radiation	These photographic records are extremely valuable and this part of the work should certainly be expanded

	Changes or Remarks
V. POST-SHOT RADIATION MEASUREMENTS	
1. Gamma ray sentinels	-
2. Portable chamber observations in high gamma flux region	-
3. Dust-borne product survey	-
4. Airborne products	See II-3-b
VI. METEOROLOGY	Vitally important and the sooner the group starts at a new site, the better.

Additional suggestions by P. B. Moon follow:

"1. That ionization sentinels, signalling by radio instead of by line, be taken out and deposited in the field <u>after</u> the shot in addition to those of the previous type that were installed before the shot. In this way readings could be obtained from the area of the crater. The sentinels could be taken out by the lead-lined tanks. This suggestion was made to me by F. Oppenheimer.

"2. That in order to elucidate the remarkable fogging of films buried five feet underground, specimens of suitable neutron-activatable and gamma-activatable radioactive indicators be buried at various depths and distances and recovered for examination after the shot. This suggestion was appended by me to the LA-430 report on our attempts to obtain gamma-ray kinephotographs (appendix Ser. No. 51).

"Weisskopf has since suggested that photographic films might also be buried."

11.1-2 Airborne Drop Test

Recommendations for tests which from past experience could be accomplished for an airborne drop are as follows:

	Changes or Remarks
I. IMPLOSION	
1. Detonator Asimultaneity	This is difficult and was not licked in the period November 1944-July 1945
2. Shock wave transmission time	This could be handled by an amplitude modulated transmitter. A continuous low amplitude signal from the bomb would give a recorder something to tune on; the first detonator increases the amplitude; the explosion kills the transmitter entirely.
3. Multiplication factor (α)	No airborne scheme has yet been suggested which could compete with the Rossi method on the ground or in the air. The two chamber method might be feasible.
II. ENERGY RELEASE by Nuclear Measurements	
3(b). Collection of fission products and Pu or 25 on filters from planes at high altitude	See LA-418 and associated reports (appendix Ser. No. 36A-D).
III. DAMAGE, BLAST AND SHOCK	
BLAST	
2. Condenser gauges (a, b)	-
4. Peak pressure (d) - aluminum diaphragm box gauges	This is an inexpensive and reliable method for blast measurement.
5. Remote pressure barograph recorders	Necessary for legal reasons
8. Shock wave expansion	If possible, airborne and ground-located cameras.

Changes or Remarks

EARTH SHOCK

1. Geophones — For scientific interest

2. Seismographs - Leet — For legal reasons

IGNITION OF STRUCTURAL MATERIALS

IV. GENERAL PHENOMENA

1. Behavior of Ball of Fire (a, b, c, d, e)
2. Rise of Column (a, b)
3. Mushrooming and Lateral Movement (a, b, c)

(Important and should be expanded)

V. POST-SHOT RADIATION MEASUREMENTS

1. Gamma ray sentinels — One set in place; one set introduced afterwards.

3. Dust-borne product survey — -

4. Airborne products — See II-3-b above

VI. METEOROLOGY — Extremely important

11.2 PREPARATIONS AND ADMINISTRATION

1. A firm directive should be obtained for a test at least six months in advance for operations within the continental limits of the United States. This assumes that a location for the test has been agreed upon.

2. A firm agreement should be obtained from the higher administration on personnel policy and the procurement of personnel. J. R. Oppenheimer gave 100% backing to the transfer policy he initiated.

3. It is essential to have a first-class man in charge of "services" and to have all services under one head. J. H. Williams did a supreme job in this work.

4. It is essential to have the base camp installations complete four months prior to the date of the test.

5. The wiring should be complete at the latest one month prior to the test, which means that 90% of the requirements should be known four months prior.

6. No new experiments should be introduced later than six weeks prior to the test.

7. NO NEW EQUIPMENT OF ANY KIND, ELECTRICAL OR MECHANICAL, SHOULD BE INSTALLED OR REMOVED AFTER THE FIRST TEST REHEARSAL except as required to minimize pick-up and interference encountered in the first rehearsal.

8. An examination of the organizatiin of TR-1, TR-2, TR-3, etc., will give a realistic estimate of the minimum number of men required per job and per experiment.

9. There should be increases in the timing staff. The large amount of testing and calibration made it very difficult for one man to carry the load. Both J. L. McKibben and E. W. Titterton were overloaded almost beyond human endurance for the period of two weeks preceding the test. Eighteen hours a day, for two weeks, is too much, and whoever takes their position should have two aides with nothing else to do but keep up to date on the system and aid in the installation, test and calibration work.

10. The same applies to whoever takes Sgt. Jopp's position; he was called upon day or night whenever any emergencies arose such as broken wires, or when unauthorized and unreported splicing

of wires was done by some irresponsible person in a hurry. Shooting is much too good for anyone who crosses up the wires. All changes in the wiring must be channelled through one office., in our case, Sgt. Jopp.

11. All shielding of equipment within a range of 1000 yards for a 20,000 ton gadget should be gas tight, and if earth covered, a concrete apron and shield must be provided. There is evidence at 300 yards that radioactive gases were blown into equipment and cooled and condensed there. At 800 yards earth embankments were scoured away, which decreased the shielding for delayed radiations.

12. Whoever has the over-all responsibility for the test should insist on review power over any newspaper releases to make sure the facts, if any, are correct and to avoid the tripe and incorrect statements which appeared in the official release.

13. The FM Motorola radios are perfectly satisfactory day and night within a 15 mile radius, and there are many cases where they did good duty up to 40 miles. However, for any greater distances than 15 miles, sufficient radios of the SCR-299 type, or lighter models if possible, should be used.

14. All instruments should be started automatically by remote control. No one should have to throw any switches after the arming switches and timing sequence switches have been closed.

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DOCUMENT ROOM

REC. FROM R.R. Davis

DATE 5/9/47

REC. ✓ NO. REC. ______

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